TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. XII.

TWELFTH ANNUAL MEETING

NEW YORK, JANUARY 16-18, 1906

SUMMER MEETING

CHICAGO, ILL., JULY 19-20, 1906

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CLI.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

TWELFTH ANNUAL MEETING.

12 West 31st Street, New York City, January 16, 17, 18, 1906.

PROCEEDINGS.

First Day—Afternoon Session.

January 16, 1906.

The meeting was called to order at 2.35 P.M. by President Kent.

Secretary Mackay announced the following names of members as having been elected since the last meeting:

Chas. G. Armstrong	Member.
F. W. C. Bailey	"
Chas. H. Basshor	"
Wm. L. Bowers	"
Edward B. Denny	"
W. C. J. Doolittle	"
Willard B. Graves	"
Frederick D. B. Ingalls	"
Warren S. Johnson	"
Samuel Kauffman	"
Jas. H. Merritt	"
Wm. A. Pope	"
Frederick Sabin	"
Oliver H. Schlemmer	"
Jas. M. Stannard	"
Harry S. Welsh	"
Lewis A. Larsen	Associate.
Jesse P. Knickerbocker	Junior.
Lee Phillips	"

On motion, the reading of the minutes was dispensed with.

President Kent: The next thing on the programme is the President's address, which I will read.

PRESIDENT'S ADDRESS.

In opening the twelfth annual meeting of the Society of Heating and Ventilating Engineers, it is my great pleasure to congratulate the Society upon the progress it has made during the past year. The reports of the Secretary and of the Board of Governors will show that the membership has increased more rapidly than in any preceding year, and the annual and semi-annual meetings have been attended by greater numbers than ever before. The Society having lived and grown for twelve years, may now be said to have satisfactorily proved that it has a reason for existence, and its future steady growth may safely be predicted.

I desire in this address to give expression to a few facts concerning the present status of the heating and ventilating art. During the last twelve years, or since the Society was founded, there has been a notable advance in heating and ventilating practice, but a very trifling advance in scientific research, and still less in the reduction of the results of research to formulas, theoretical or empirical, which can conveniently be used in practice.

The advance in practice has been due to necessity. The demand for larger and more effective and more reliable apparatus springs first from the increased wealth of the country, which causes the erection of larger and more costly buildings; second, from the increase of luxurious habits of the people, requiring more heating and ventilating and less trouble in manipulating or regulating the apparatus; third, in the better education of the people as to the desirability of thorough ventilation. This demand has stimulated designers and manufacturers of heating and ventilating apparatus to improve their methods and their results.

So far as simple heating is concerned, the modern heating and ventilating engineer finds no difficulty in designing a system, either direct or indirect, live steam or exhaust steam, or hot water, which will carry heat to any distance desired and deliver it in one or many rooms, heating them to 70 degrees or more

when the outside temperature is 20 degrees below zero. Even the warm air or furnace system is capable of accomplishing the same results when reinforced by electrically driven fans, when the distance is not too great. The only limit that is fixed in heating a building or a group of buildings is the limit of cost fixed by the owner.

The problem of ventilation, however, is a much more difficult one for the designer. It is easy enough to ventilate properly a large single chamber, such as a church, a cathedral, a theatre or a stock exchange, but when a large building of several rooms, such as a public school, or a court-house, or a hospital, or a sky-scraper building, is to be ventilated, the problem becomes very complex, and it cannot be said that any general solution of it has yet been found. Each case has to be studied carefully by itself in the light of previous practice, and the record of such practice includes almost as many failures as successes. Many of these failures are due to the parsimony of the owners, who limit the cost to a figure at which it is impossible to provide good ventilation. Others are due to the failure of the architect to call in the advice of competent experts, and still others are due to the imperfect education of the experts themselves, or to their neglect to appreciate the real difficulties of the problem on which they are engaged.

Let us consider for a moment what are the difficulties of heating and ventilating a large building containing many rooms, such as a school-house or a court-house. The problem to be solved is to keep each room at a temperature of, say, 70 degrees Fahr. and the air of such purity that it contains at no time more than eight volumes of carbon dioxide in 10,000 volumes of air, or twice the amount found in the atmosphere out-doors. The mere heating of each room can be done satisfactorily by direct steam radiation with thermostatic control of the steam supply. The ventilating problem, however, is not so easily solved. Each room should have given to it a quantity of air proportional to the number of persons in the room. The means provided for supplying fresh air to the building is usually either a fan placed in the basement which pushes the air into the several rooms, the air finding its way out through foul-air exits, or else there is an exhaust fan in the attic or on the roof of the building, pulling out of the rooms the air which is admitted from the air-

inlet pipes. In the best modern practice the incoming air is warmed by steam coils in the basement before being allowed to enter the rooms. In some cases there is both a blower fan in the basement and an exhaust fan for foul air at the roof, but in all cases there is one main entrance to the building for receiving fresh air from out-doors and one main exit flue for the escape of foul air. Between the points of entrance and exit there are at least as many channels or pipes for the air to travel in as there are separate rooms. The areas of these pipes and their resistances due to friction, to right-angle bends, dampers, etc., may be calculated and adjusted so that when there is still air out-doors and the fan or fans running at a certain speed, the air delivered into each room may possibly be the amount calculated by the designer. I say " may possibly " and not " will certainly," because it is scarcely possible to design a system of a large number of pipes varying in size, diameter and length, leading from an air reservoir to another reservoir at lower pressure, in which each pipe will deliver its due proportion of air. There is bound to be more or less " short circuiting " under the most favorable circumstances.

The next trouble is that if we have the pipes so perfectly designed that each pipe under the best circumstances will deliver its own calculated proportion of air, then the circumstances for which the pipes are designed are bound to vary every hour in the day. Some one of the rooms will have a crowd of people greater than was calculated, and they will remain longer in a room, polluting the air. Some one opens a window to let out the foul air and let in fresh, and immediately the whole circulating system is disarranged and thrown out of balance. If there is a wind blowing into the room it will blow back the incoming air supply and tend to increase the air supply of all the other rooms in the building. If, on the other hand, there is still air outside and the air from the heating coils enters the room under pressure, the opening of the window will establish a short circuit for this air to get outside by the window instead of going through the exhaust flues to the roof. An excessive supply of air will enter the room on that account and one or more of all the other rooms of the building will be robbed of its proper supply. The room that is thus deprived of its proper supply will then become not only foul but overheated, and a window will

have to be opened in it in order to cool and purify the atmosphere, and this will further disarrange the ventilating system. What is needed is such a system as will not be put out of balance when the doors or windows are opened in any one or more rooms of the building.

We have means of automatically regulating the temperature of a room, but we have no means of automatically regulating the purity of the atmosphere in it. Not only this, we have as yet no means of even indicating the purity of the atmosphere in any convenient manner, such as we have in the thermometer for indicating its temperature and the aneroid barometer for indicating its pressure. An occupant of a room is not likely to notice that the atmosphere in the room is impure until the impurity is more than double what should be allowed, and even the chemical determination of the condition of the atmosphere is a matter of no little difficulty.

Another difficulty with all methods of ventilation is that while air is so easily moved by a very light pressure in sufficient quantity to provide ventilation for any room, this pressure is apt to be overcome by the action of the wind on one side of the building entering through crevices or cracks or through the porous walls, so that when the atmosphere is quiet out-doors the ventilating system may work all right, but when there is a wind pressure against the building it may be thrown out of balance.

The various complex problems of heating and ventilating are gradually being solved and the difficulties overcome by the method of trial and error. Now and then a building is erected which gives satisfactory results, and the methods used in it are copied in other buildings. Again another system is found occasionally to fail, and as the causes of failure become understood they are avoided in future designs. " Rules of thumb " are still in vogue for proportioning the sizes of every detail of heating and ventilating apparatus from the size of a grate surface and the rate of combustion of coal to the speed at which ventilating fans should be driven and the area of the pipes and registers from which they shall discharge their air. Sometimes formulas are used which are apparently based upon physical theories, but each of these formulas contains one or more empirical coefficients whose values are more or less uncertain. By the use of these formulas and rules of thumb, supplemented by practical experience, the

heating and ventilating engineer is enabled when he is not limited by cost of apparatus to provide a fairly satisfactory heating and ventilating system for almost any building, but the best of such systems are not automatic: they require constant and faithful attention on the part of the operatives in charge of them and they are expensive, both in cost of apparatus and in cost of fuel. There is a vast field for research to determine more accurate values of the coefficients to be used in our formulas and to find out how it is possible to ventilate a building with just enough air to maintain the standard of purity at what it should be without discharging from the building uselessly a great quantity of hot air over and above that required for the necessary ventilation.

Why are such tests and researches not made? The answer is that all our heating and ventilating engineers are too busy to make them. We have no national laboratory of research in which they can be made, and the imperfectly equipped laboratories in our technical colleges are scarcely as yet prepared to undertake such researches. We have had a Committee on Tests in this Society for the last ten years but it has done practically nothing, the reason always given being lack of time and lack of funds.

The literature on the subject of heating and ventilating is not yet extensive, but it is growing at a fairly rapid rate. We have but few standard text-books, but we have the annual volumes of this Society and of the younger British society. We have also a few trade and technical journals devoted to the subject, and the leading engineering periodicals occasionally contain valuable articles illustrating the most recent practice. A systematic and scientific digest of the literature of the last ten years is greatly needed, but the person who has both the ability and the time to make such a digest is not easily found. It might prove a good investment for one of our publishing houses to find such a man, pay him for his time, and get him to write a thorough treatise, covering both theory and practice.

The scientific study of heating and ventilation has been begun in a few of our technical colleges as a branch of the general subject of mechanical engineering, but the greatest amount of time that can be devoted to it is two or three hours a week for one-half year. An excellent description of such a course is given in the paper by Professor J. D. Hoffman of Purdue University,

published in the 1903 volume of our Proceedings. Not much practical work or research can be expected from so brief a course, but great good from it will ultimately result to the profession from its giving to a large number of engineering graduates each year an introduction to the subject and some knowledge of its fundamental principles upon which they can build later when they enter into practice. It also tends to the diffusion of knowledge on the subject among the general public and to the increase of public sentiment in favor of improvement in ventilation. It is to be hoped that before long some engineering college may find it convenient to offer a post-graduate course in heating and ventilating to a few mechanical engineering graduates who shall have had a year or two of practice in the heating and ventilating business before entering upon the course.

The architectural profession is being gradually educated to the advisability, or the necessity, either of employing consulting engineers on all important work or else of architects associating themselves with engineers as partners. The time seems to have arrived when the profession of architecture should be divided just as the engineering profession has been. We no longer have general engineers who are competent unaided to undertake the design of every detail of a plant which shall include in it matters belonging to several branches of engineering, such as civil, mechanical and electrical; we no longer have railway engineers, but engineers of maintenance of way, of motive power, and of electrical transmission and motive power. So also we should have artist architects, who could revel in designs of exteriors and interiors, and engineer architects, and these last should be divided into structural engineer architects, who would design the foundations and the superstructure, and architectural mechanical engineers who would have to do with boilers and chimneys, pumps and piping, elevators, electric lighting, and heating and ventilation. The ideal arrangement, of course, would be the association of these three kinds of men in partnerships, styled "architects and engineers." It ought to be generally recognized that no good artist can be an engineer and no good engineer an artist.

The Society is to be congratulated on the fact that, due to its efforts, two States—New York and Pennsylvania—during the past year have passed laws leading toward the securing of a

reasonable amount of ventilation in schools hereafter to be built in these States. It is to be hoped that the Society will continue its efforts in this direction, and that other States will soon follow the example set by New York and Pennsylvania.

The Pennsylvania law states that no school-house costing in excess of $4,000 shall be erected by any board of education or school district in the State until the plans and specifications shall show in detail the proper heating, lighting and ventilating of the building. "School-houses shall have in each class room at least 15 sq. ft. of floor space and not less than 200 cu. ft. of air space per pupil, and shall provide for an approved system of ventilation by means of which each class room shall be supplied with fresh air at the rate of not less than 30 cu. ft. per minute for each pupil."

The New York law applies to school houses erected in cities of the third class, incorporated villages and school districts, and to additions to such school houses costing more than $500. It provides that the plans and specifications shall show in detail the ventilation, heating and lighting of such buildings, and that they shall be submitted to the Commissioner of Education who shall not approve them "unless the same shall provide at least 15 sq. ft. of floor space and 200 cu. ft. of air space for each pupil," and "unless provision is made therein for assuring at least 30 cu. ft. of pure air every minute per pupil, and the facilities for exhausting the foul or vitiated air therein shall be positive and independent of atmospheric changes."

These two laws are good as far as they go, in requiring that plans and specifications for school houses shall provide for an approved system of ventilation by means of which 30 cu. ft. of air per minute shall be supplied to each pupil. Something more is needed, however, and that is an investigation by engineers of the Board of Health of each State to discover whether or not all the class rooms in schools built under the specifications of these laws are actually supplied with the 30 cu. ft. of air per pupil in every minute, independent of conditions of wind or weather. These engineers should also report upon the best means of measuring the air supply to each room, and the best means of regulating the supply in different class rooms, in case any one of them should be receiving more or less than its proper supply.

The chemists and physicians of the boards of health might

also do a valuable service for the rising generation in making observations and experiments to determine whether or not the introduction of 30 cu. ft. of air per minute per pupil is sufficient to keep the purity of the air at the desired standard in all parts of the room, during the last two hours of the school period, and whether this amount of ventilation is sufficient to prevent that depression of vitality with tendency to ill health which follows the long-continued breathing of a slightly foul atmosphere.

The Society has done a great deal of good work during the last twelve years, but it is only a mere beginning. I have already hinted at some of the work that lies before us. There are other things yet to be done. Let us double our present membership in the next five years. It can easily be done. Let us encourage the young men especially to join. Ten years hence they will be the leaders of the profession. Let us have our midsummer meetings as far west of New York City as possible, to let people know that we are a national society. Let us start a "question box," following in a mild way the example of the Ohio Gas Light Association, which has just issued its third question box annual volume, a book of 900 pages, containing no less than 4,920 answers contributed by 519 contributors to 567 questions. If we could have a question box of only one-tenth this size, what a valuable thing it would be. Our Committee on Furnace Heating started a series of questions nearly a year ago, but only two replies have thus far been received. It is a rather slow beginning, but we hope for better results in the coming year. It takes time to get engineers in the habit of devoting a small portion of their valuable time to the public service without compensation, but if the Ohio Gas Light Association can get 519 different people to answer its questions on such a subject as gas, why can not we get one-tenth of that number on the more vital subject of fresh air, a subject that is of the utmost importance to the health of the community?

Let the good work of the Society go on, and we shall soon have an organization of which we may be proud, not only on account of its numbers, its resources, its professional standing among other scientific societies, but above all on account of the work it has done and is doing for the advancement of the science and the art of heating and ventilation and for the benefit of the health of our fellow men.

The Secretary then read the following report:

SECRETARY'S REPORT.

New York, January 16, 1906.

The American Society of Heating and Ventilating Engineers:

Gentlemen: Your Secretary would report an increase in membership during the past year. At our last annual meeting our membership was composed of 198 members, 1 Honorary member, 16 Associates and 5 Juniors, or a total of 220 members of all grades. During the year we have added 30 members, 3 Associates and 3 Juniors. Four members have been dropped from the roll for non-payment of dues, 6 members and two associates have resigned, and James Curran, a valued member of our Society, who was elected December 9, 1901, died October 27, 1905. Our present membership is 217 members, 1 Honorary member, 17 Associates and 8 Juniors, or a total of 243 members of all grades, making a net increase of 23 during the past year.

The financial affairs of the Society are in good condition. At the last annual meeting there was a balance in the hands of the Treasurer of $684.19. We have received from all sources during the past year $2,542.75, which, with the balance on hand, made a total of $3,226.94 available.

The total expenditures amounted to $2,593, leaving a balance in the hands of the treasurer of $633.94.

There is a balance owing from members for dues, etc., and from newly elected candidates for membership for initiation fees and dues, amounting to $1,150, which, with the balance on hand, amounts to $1,783.94. The principal reason for the large amount owing is that the last ballot was delayed and $485 of this only became due on the 15th inst., so that the actual old balance owing by members is $665, or about the same as last year.

We have no unpaid bills except those in connection with the present meeting, which have not been presented.

The members dropped from the rolls during the year owed the Society a total of $120.

The Secretary's expenses for the year, including stenographer, clerk hire, rent of post-office box, expenses in connection with the summer meeting, postage, expressages, etc., amount to $629.44.

The 1904 Proceedings were sent to the members in December, 1905, and the 1905 Proceedings are now being edited and corrected and will be forwarded to the members as soon after this meeting as possible. The cost of the editing and printing of these Proceedings will amount to about $800.

The Society held a very successful meeting at Chicago, Ill., July 7 and 8, 1905, being the most largely attended summer meeting we have ever held.

All the papers to be presented at this meeting, while received late, have been printed and forwarded to the members, and in connection with this I would mention that on account of shortness of time it was impossible to send the different papers forward to the authors for correction, and as a result errors or printer's mistakes will be found in many of the papers. I would urge for future annual and summer meetings that those intending to present papers arrange to have them in the Secretary's hands at least sixty days previous to the date of the meeting. That would give ample time to have them properly edited, cuts prepared, give the author an opportunity to correct them and get them into the members' hands in corrected form three or four weeks in advance of the meeting, enabling them to become familiar with the papers before the meeting, which is really the intention in printing them instead of having them read from manuscript.

Respectfully submitted,

W. M. Mackay,

Secretary.

The Treasurer's report was then read, as follows:

TREASURER'S REPORT.

January 16, 1906.

Balance on hand January 17, 1905		$684 19
Cash received since January 15, 1905:		
Dues	$2,109 60	
Initiation fees	310 00	
Pin badges	10 25	
Electrotypes	60 00	
Proceedings	45 00	
Interest on deposits	7 90—	2,542 75
Carried forward		$3,226 94

Brought forward		$3,226 94
Disbursements:		
U. G. Scollay, Treasurer's account	$12 91	
Wm. M. Mackay, Secretary's account	100 74	
W. M. Mackay, Secretary's salary	250 00	
W. M. Mackay, Secretary's account	629 44	
W. Kent, editing 1904 Proceedings	100 00	
Expenses annual meeting	80 00	
J. J. Little & Co., printing	856 06	
Schoen & Kellerman, printing	206 35	
Bormay & Co., cuts	150 45	
Williams Engraving Co., cuts	3 25	
Harold Godfrey, reporting annual meeting	94 00	
George H. Lambert, reporting annual meeting	71 85	
E. M. Bloomer, certificates	21 95	
Empire State Surety Co., Treasurer's bond	6 00	
A. B. Reck, dues returned	10 00	—$2,593 00
Balance on hand		$633 94

Respectfully submitted,

U. G. Scollay,

Treasurer.

The Secretary then read the report of the Board of Governors.

REPORT OF THE BOARD OF GOVERNORS.

New York, January 16, 1906.

Gentlemen: Your Board of Governors met and organized January 21, 1905, appointing a Committee on Finance, Membership and Publication, and an Executive Committee. The various committees have given careful attention to their duties, and the Board has met as often as was found necessary during the year.

We are able to report an increase in membership, and that the financial affairs of the Society are in good condition, with sufficient funds on hand to pay for the publication of the 1905 vol-

ume, which has been delayed, but which will be forwarded to the members as early this year as possible.

As a number of our members in arrears owe two years' dues, which, in accordance to the constitution, disqualifies them and prevents us from placing their names in the 1905 directory, while the usual custom has been not to drop their names from the rolls until February 1st, when they would owe $30, it was decided not to publish the pocket list of members until after the close of this meeting, when it will be correct, more valuable to the members and will have no unqualified members in it.

A summer meeting was arranged for July 7 and 8, 1905, at Chicago, Ill., which proved successful in every way.

All the papers to be presented at this meeting have been printed and forwarded to the members.

Respectfully submitted,

William Kent, Chairman,
R. P. Bolton, Vice-Chairman,
C. B. J. Snyder,
B. H. Carpenter,
B. F. Stangland,
Jas. Mackay,
A. B. Franklin,
J. C. F. Trachsel,
W. M. Mackay, Secretary.

President Kent: Next is the report of the Committee on Legislation.

The report of the Committee on Legislation was read by B. H. Carpenter. Numerous letters, Acts of Assembly, etc., accompanied the report, which were not read.

REPORT OF COMMITTEE ON COMPULSORY LEGISLATION.

To the American Society of Heating and Ventilating Engineers:

Gentlemen: Your committee has continued to make as much progress as was possible in regard to the adoption by the various States of laws that would also include requirements of proper ventilation in public buildings and public school houses. There has been a large amount of quiet work done in this line by many members of this Society who are not on this Committee in addi-

tion to what its members have done. The three principal Eastern States, New York, New Jersey and Pennsylvania, have all passed laws to that effect, and we know that Mr. S. A. Jellett, Mr. B. H. Carpenter, Mr. C. B. J. Snyder, W. M. Mackay and Professor Kent have all done a great deal of personal work in aiding and securing the passage of the bill in the Pennsylvania Legislature. The following is a copy of the Act, which has passed both houses and was signed April 22d last by Governor Pennypacker:

AN ACT

Entitled an act for the purpose of governing the construction of public school buildings in order that the health, sight and comfort of all pupils may be protected.

Whereas, it is of great importance to the people of this Commonwealth that public school buildings hereafter erected by any board of education, school trustees or school directors shall be properly heated, lighted and ventilated.

Section 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania, in General Assembly met, and it is hereby enacted by the authority of same. That, in order that due care may be exercised in the heating and ventilating of public school buildings hereafter erected, no school house shall be erected by any board of education or school district in this State, the cost of which shall exceed four thousand ($4,000) dollars, until the plans and specifications for the same shall show in detail the proper heating and ventilating of such building.

Section 2. Light shall be admitted from the left or from the left and rear of class rooms, and the total light area must, unless strengthened by the use of reflecting lenses, equal at least twenty-five per centum of the floor space.

Section 3. School houses shall have in each class room at least fifteen square feet of floor space and not less than two hundred cubic feet of air space per pupil, and shall provide for an approved system of heating and ventilation, by means of which each class room shall be supplied with fresh air at the rate of not less than thirty cubic feet per minute for each pupil and warmed to maintain an average temperature of seventy degrees Fahrenheit during the coldest weather.

A copy of the Act as passed by the State of New Jersey is herewith attached.

Mr. T. J. Waters of the Department of Heating, Ventilation and Sanitary Engineering of the Board of Education in the City of Chicago, also a member of this Committee, has compiled a bill to be presented to the Legislature of Illinois, but was unable to have it presented in time for action by the Senate or House of Representatives, but we trust it will be presented at the next meeting of the Legislature. A copy of this bill is herewith attached.

We have also placed this matter in the hands of those whom we thought would be the best parties to bring this subject before the Legislature of the State of Michigan, and hope to have it passed at the next session. We think that as the three leading eastern States have adopted compulsory legislation, that the other States will see it to their advantage to do likewise.

Respectfully submitted,

ANDREW HARVEY, Chairman,
C. B. J. SNYDER,
S. A. JELLETT,
T. J. WATERS,
B. H. CARPENTER.

The first enclosure is a copy of the Act passed at the second special session of the Legislature of New Jersey, October, 1903, entitled

An Act to establish a thorough and efficient system of free public schools, and to provide for the maintenance, support and management thereof.

The following are the clauses relating to heating, ventilation and lighting:

In order that due care may be exercised in the heating, lighting, ventilating and other hygienic conditions of public school buildings hereafter to be erected, all plans and specifications for any such proposed school building shall be submitted to the State Board of Education for suggestion and criticism before the same shall be accepted by the board of education of the district in which it is proposed to erect such new building.

In order that the health, sight and comfort of the pupils may

be properly protected, all school houses hereafter erected shall comply with the following conditions:

I. Light shall be admitted from the left, or from the left and rear of class rooms, and the total light area must, unless strengthened by the use of reflecting lenses, equal at least twenty per centum of floor space;

II. School houses shall have in each class room at least eighteen square feet of floor space and not less than two hundred cubic feet of air space per pupil. All school buildings shall have an approved system of ventilation by means of which each class room shall be supplied with fresh air at the rate of not less than thirty cubic feet per minute for each pupil;

III. All ceilings shall be at least twelve feet in height.

The second enclosure is a copy of the bill to be presented to the Legislature of Illinois. It is as follows:

An Act to provide for proper sanitation and ventilation of schóol-houses and other public buildings.

Be it enacted by the people of the State of Illinois, represented in the General Assembly:

Section 1. Every school-house and other public building hereafter erected in a city or incorporated village within this State shall be provided with a reasonably sufficient number of proper water closets, lavatories, earth closets or privies, for the use of persons occupying or admitted to such school-house or public building; shall be kept clean and free from all noxious smells or gases arising from any closet, drain, privy or other nuisance, and shall be provided with proper means for ventilation in such manner that there shall be at all times a sufficient supply of pure air therein.

Section 2. Prior to the erection or construction of any school-house or public building, the person or persons or corporation owning the same shall submit a full and complete copy of the plans, together with a statement in writing of the proposed building, which statement must contain a clear and comprehensive description properly sworn to by said owner or authorized representative of those portions of the proposed work which deals with the sanitation and ventilation of said proposed buildings. Such details, statement and copy of the plans shall be submitted to and filed with the department of buildings, health board or

other officer or officers having like jurisdiction, within an incorporated city or village where said buildings are about to be erected, and in all other places, including any city or incorporated village not having an officer or officers exercising jurisdiction as a board of health or health officer, such detailed statement and copy of plans shall be submitted to and filed with the State board of health. No such school-house or other public building shall be erected or constructed until such specifications and plans shall have been approved in writing by the department of buildings, board of health or officer exercising jurisdiction thereof, to whom such plans shall be submitted as required by this act. The sanitation and ventilation of every school-house or other public building, as provided by this act, shall be subject to the inspection of such board of health or other officer exercising like jurisdiction during the progress of such erection or construction, by its or his agents or servants, and shall conform in all things to the reasonable requirements of such board of health or other officer of like jurisdiction.

Section 3. Every such school-house and public building for which a detailed statement and plans are filed as provided by this act shall be ventilated in such a manner that the quantity of foul or vitiated air exhausted or removed shall be positive and independent of atmospheric changes, and shall not be less than thirty cubic feet per minute for each person; and the quantity of fresh air admitted shall be not less than thirty cubic feet per minute for each person which such schoolroom and public building can accommodate.

Section 4. It is further made the duty of such department of buildings, board of health, health officer or other body or person having jurisdiction, to have such inspection made from time to time as may be deemed necessary, to see that such school-houses and public buildings as are built in compliance with this act are kept and maintained in a proper sanitary condition and that the provisions of this act are complied with. Should said inspection determine the fact that the provisions of this act are not being complied with, said department of buildings, health board or health officer, or other officials exercising jurisdiction shall at once issue a written order to the trustees, corporation or public officers having charge of, owning or leasing said school-house or public building, requiring the immediate correction of

the violation found, giving a reasonable time for such correction.

Section 5. The word school-house as used in this act shall be taken and deemed to mean any building in which public or private instruction shall be given to not less than ten pupils at one time; and the words public building as used in this act shall be taken and deemed to mean any building or premises used as a place of public entertainment, instruction, resort or assemblage, or for the purpose of transacting public business of any kind or nature whatsoever, when there shall be more than ten persons in any such building at any one time. Provided, however, that this act shall apply only to cities and incorporated villages.

Section 6. Any public officer or corporation or other person or persons found guilty of violating the provisions of this act shall be guilty of a misdemeanor and shall be punished by a fine of not less than $100 nor more than $500, or by imprisonment in the county jail for a period of six months, or both.

On motion the report of the committee was received.

Mr. Blackmore then read the report of the Committee on Standards.

REPORT OF THE COMMITTEE ON STANDARDS.

New York, January 16, 1906.

President and Board of Managers,

American Society of Heating and Ventilating Engineers.

Gentlemen: On behalf of the committee appointed on standards, I beg to make report as follows:

Two matters were referred to this Committee for action since the last annual meeting. One of these references was the adoption of a list of abbreviations for use in specifications similar to that adopted by the electrical engineers at their last annual meeting. The other was the question of adopting a list of standard sizes of steam pipes for given quantities of radiation. This was referred to the Committee by resolution at the semi-annual meeting.

Your Committee considered both these questions. In re the first question as to abbreviations, the general opinion of your Committee is that the art is not sufficiently advanced at this time, nor yet have a sufficient number of standards been adopted by which such list of abbreviations could be made that would be

reasonably satisfactory to the various engineers throughout the country.

Your Committee, therefore, think this matter should be carried forward and be acted upon as the progress of the art seems to demand.

The question of adopting a standard list of sizes for steam pipes is one surrounded with many difficulties, and your Committee are not at all unanimous on a recommendation for this purpose.

There are so many different systems in use requiring different size mains for different conditions and for different methods of installation that your Committee do not feel that they can recommend a standard at the present time that will be at all satisfactory to the entire Society or to the engineering trades.

Respectfully submitted,

J. J. BLACKMORE, Chairman.

On motion the report was received.

The report of the Committee on Tests was read by Secretary Mackay.

REPORT OF COMMITTEE ON TESTS.

At the outset it seems advisable to give, as a matter of record, the status of the Committee on Tests.

Your Committee is advised by the Secretary that at the first annual meeting of the Society it was decided by a vote of the members that we should have standing committees appointed yearly on Compulsory Legislation, Uniform Contract and Specification, Standards and Tests, so that, while nothing appears about it in the constitution which was framed some four or five years later, it has been considered as necessary as the election of officers from year to year.

When first appointed, it was hoped that the Society would be in a position to devote a certain amount of money every year, particularly to the Committees on Standards and Tests. Later, when it was found that there were not sufficient funds on hand to pay for them, it was hoped and suggested that members making tests would report them to the Society through this Committee, and so it has gone on from year to year, new committees

being appointed by each incoming president, merely reporting progress at the end of the year and no tests reported or asked for.

In Vol. X. of the *Transactions* of the Society, just published, your Committee notes a statement by Professor Carpenter, then chairman, that the Society cannot afford to do any testing where there is competition; that it cannot afford to act as judge or umpire in any case of that kind; there is no glory in it, and there is certainly little satisfaction in it, and there would be a good deal of unpleasant responsibility to assume.

Your Committee concurs in this statement as applying to the testing of boilers, radiators and the like of rival makes and making public the results of such tests. This is the work of a regular consulting engineer rather than that of the Committee on Tests.

Furthermore, this Committee has no funds at its disposal, which in itself precludes the making of such tests. It appears that about all the Committee can do under the circumstances is to make suggestions as to what tests it is desirable to make, to urge members to make them, and if they do not present the results to the Society as a paper to send the data to the Committee, which when a sufficient number of data on any particular subject has been received will combine them and present them in the form of a report. In other words, let the Committee on Tests be the depository for data on tests collected by members, these data to be worked up from time to time and incorporated in its reports. These suggestions are, however, open to the criticism that so many tests are conducted carelessly that the results obtained are likely to be unreliable. It would be very difficult for the Committee, in many cases, to determine what is correct and what is not correct. Certainly the Committee would not wish to offer any information to the Society which is not reliable, and unless tests are made by men who have had experience in this line it is doubtful if the information secured would be of much value.

While this criticism is, in the main, true, nevertheless, if no other purpose were served at first, the submitting of reports of tests of any kind to this Committee would enable it to point out to members any shortcomings in their methods of making the tests and the collection and tabulation of a number of tests of the same kind would bring out points of interest and value, and would suggest lines of investigation to be followed up.

If the Committee on Tests can stimulate an interest on the

part of members of this Society in the making of tests, can outline the manner in which such tests should be conducted and can specify what data should be obtained, it would appear that there might be some excuse for its continued existence.

Possibly more could be accomplished by the appointment of special committees for specific purposes, like the one appointed last January to collect data on furnace heating, rather than to expect the Committee on Tests to take the initiative in such investigations.

Your Committee, for reasons stated above, has no report to make of tests conducted by its members, and regrets that no record of tests made by others has been received, but hopes that members will in future bear in mind that this Society has a Committee on Tests which could be of service in collecting and tabulating the results of various kinds pertaining to our branch of engineering.

(Signed) COMMITTEE ON TESTS.
WM. G. SNOW, Chairman,
R. C. CARPENTER,
A. A. CARY,
J. A. ALMIRALL,
H. H. RITTER.

January 16, 1906.

On motion the report was received.

President Kent appointed the following gentlemen as tellers of election: Frank G. McCann, H. A. Wilson and N. P. Andrus.

President Kent: New business is the next thing in order. Has any one any new business to bring forward?

Secretary Mackay: We might consider the place for next summer's meeting.

President Kent: Are there any remarks to be made on the subject of next summer's meeting? If there are, it might be as well to discuss the time and place for next summer's meeting as anything else.

Secretary Mackay: We have invitations from Milwaukee, Chicago, Denver, Atlantic City, Columbus, Ohio, and London, England.

President Kent: We would like to be present with the British engineers in London, in July, but I do not think we are ready yet to hold our meeting in London.

Secretary Mackay: We have some thirty odd members over there, twice a quorum.

Secretary Mackay read a letter from Chicago inviting the Society to come there.

Mr. Brennan: I believe Milwaukee would like very much to have the meeting held in that city, and we will do our best to see that the members have a good time. It is a nice summer resort, and I know all would enjoy themselves.

Mr. Barron: I suggest that the Board of Governors be requested to select Milwaukee for the semi-annual meeting place, with discretion of having the meeting in Chicago if they think best.

Mr. Scollay moved the matter be made a special order of business, to be taken up the last day of the meeting. Carried.

President Kent: Sometimes under "new business" the "good of the order" is taken up, and we discuss what we can do to improve the efficiency of the Society. Has any one any remarks to offer upon that subject?

Mr. Chew: The semi-annual meeting in Chicago last year was very enthusiastic. Many of the members in the West did not know the Society is incorporated and that its annual meetings must be held where the incorporation papers are taken out, and that was the only reason why the annual meeting of this Society is always held in New York City. I don't think this Society can do anything better than to hold the semi-annual meeting somewhere west of Pittsburg.

Mr. Samuel R. Lewis: I came into the Society at last summer's meeting, in Chicago, and was surprised at the interest manifested by every one there—from Dakota, Missouri and Iowa, and I felt very sure that if the meetings in the West are continued there will be a great increase in membership. A great many people have been talking about it.

Mr. J. A. Donnelly: Referring to the report of the Committee on Tests, I would like to make a suggestion that the Committee take up the question of standard sizes for steam mains and steam pipes. It may not be possible to adopt a standard, but it may be possible to get a great many facts and classify them so that much light may be thrown on the subject. The members of the Society and the heating trade in general might be invited to submit written discussions upon the possibility of standard sizes of steam mains for the summer meeting.

Mr. J. Gormly: I would suggest the Society has now a Committee on Standards. The Master Steam Fitters' Association has been working with another committee and the manufacturers have been working on the same idea. They are more likely to arrive at something of value, and I think our committee should be instructed to work in conjunction with these other committees.

Secretary Mackay: Mr. Gormly suggested that we work with the Committee of the Master Steam Fitters' Association. My belief is they have organized a Committee on Standards to get full-weight fittings and full-weight valves, standard size of flanges, number of bolts, etc., while what Mr. Donnelly wants is sizes of steam mains for steam and hot water. The steamfitters, as I understand it, are not going to touch upon that. If they are working as a committee on standards of weights and materials, then what Mr. Donnelly suggests would not have any weight in the matter at all.

Mr. Gormly: Their purpose is to standardize the sizes of everything, as I understand it. For instance, the thread on a pipe may be two inches long and you can run that pipe into the valve and twist the seat clear out. That is one feature of standardizing they are trying to cover. Some threads are cut deep and go into the valve before they come to a bearing.

Mr. J. A. Donnelly: So far as the Committee on Standards goes, last year they prepared a typewritten sheet of paper, which is the entire committee's labor—one sheet of typewritten paper. I think the members would be fully as liable to prepare a paper upon that subject as anything else. There are members, no doubt, who have in mind some paper for the summer meeting, and I think some would take up this topic and write upon it for the summer meeting. As to Mr. Gormly's remark as to the Committee from the Steam Fitters, his view is correct, and yet there is another question. Their work is on articles of manufacture, upon how materials shall be best constructed, and not as to the use of materials afterward. They will not standardize the thickness of flanges, etc., and I don't think they care to adopt a paper stating how packing should be inserted between the flanges or how bolts should be drawn up or how pipe should be used after being made correct. These are technical questions which come in the province of the heating and ventilating engineer, or, in other words, an engineering question. The questions the steamfitters

take up are mercantile questions, questions of manufacture, the dealing with materials and their preparation prior to their coming into the steamfitter's hands. So I think each society has its field in the question of standards. There are some things taken up by the Master Steam Fitters which could well be considered by the ventilating engineer, and there are many engineering questions that the Master Steam Fitters would not care to take up as being too technical for them.

Mr. J. J. Blackmore: Mr. Donnelly thinks we should adopt standard sizes for steam mains. I think pretty strongly upon the subject myself. I think we ought to adopt a standard, but before we do it we should be sure the standard is correct. I have talked this over with engineers and there are scarcely two of the same opinion. When there is a wide difference among engineers as to sizes, I do not think the art has advanced to that stage where we can, as a Society, recommend a standard. I believe in keeping the question agitated, and perhaps it would be better to refer it back to the Committee on Standards or a sub-committee, as you think best, but I do not think the various interests in the Society will come to any conclusion that will allow us to adopt a standard that will be satisfactory.

President Kent: I think the best solution of this question now is to postpone it until the last session of this meeting, and in the meantime by conversation we can get some ideas out of the members. I have two suggestions here in the shape of topical discussions in addition to those printed in the programme, which will come up in proper time, but these we can take up now if we wish to.

> "Is it possible to make a small float for some types of air valves that won't collapse and become water-logged?
>
> "Why should a steam-heating contractor, working under plans and specifications of an expert consulting engineer, be compelled under his contract or any clause in the specifications to guarantee the working of his job, the temperature, or the specific amount of air, for the heating or ventilating of any particular room in the structure?"

Mr. Scollay: I move the discussion of floats be postponed. Carried.

The second question was again read. It was discussed by Messrs. Barron, Payne, Scollay, Brennan, Rutzler, Davis, Donnelly and Secretary Mackay.

Mr. Barron: I move it is the sense of this meeting that the heating engineer take the responsibility for satisfactory performance of the work where he is the designer. That it be the sense of this meeting that in all work designed by a heating engineer he shall assume responsibility for the satisfactory performance of the apparatus.

The motion was duly seconded.

A Member: I do not think there is an engineer in the room who has ever acted as a consulting engineer who would assume that responsibility. I know the contractor feels very keenly in this matter, and it should be discussed here and with the Master Steam Fitters.

President Kent: Even if we have a right to pass this motion is it good policy for this meeting of the Society, consisting of probably thirty or forty out of a membership of two hundred or over, to express our sense in regard to the ethics or duties of one branch of the profession, that of the consulting engineer? Is it good policy for us to deliberately take such action affecting a large body whom we are hoping to get into the Society?

Mr. Thompson: I move to amend Mr. Barron's motion to the effect, providing the consulting engineer has full power to award the contract and also superintend the construction of the work.

The subject was further discussed by Messrs. B. H. Carpenter, Rutzler, Scollay, Gormly and Barron.

President Kent: There are a great many other sides to be brought out, and taking all the facts in consideration I will declare the motion out of order. I don't believe we should put on record in our Society a statement like that in the motion, even when it is amended so that the engineer be superintendent of the work.

Mr. Barron: Before you declare that motion out of order I want to withdraw it.

Mr. Rutzler: I appeal from the decision of the Chair.

The President requested Secretary Mackay to put the question.

The question being shall the decision of the Chair be sustained, Secretary Mackay put the question, which resulted in a tie vote, the decision of the Chair being sustained.

(President Kent resumed the chair.)

The topic was then further discussed by Messrs. James Mackay, Scollay, Rutzler, Barron and Secretary Mackay.

President Kent: We will now have Topic No. 3: "Is there any advantage in placing check-valves on return connections of steam radiators, discharging into a single down pipe from an overhead steam main, returning to a receiver, and, if so, can check-valves be used of smaller size than the return connection?"

Secretary Mackay: This topic was suggested by Mr. Feldman.

(Secretary Mackay read a written discussion on the topic by Mr. Feldman.)

President Kent: Next is Topic No. 4: "The advantage of automatically venting the extreme ends of steam mains in the basements on low pressure gravity steam-heating apparatus, and the proper mode of connection."

The topic was discussed by Secretary Mackay and Mr. Harding.

Secretary Mackay read a communication from the American Society of Civil Engineers granting the Society the use of their rooms and other privileges, and Mr. Wolfe moved the communication be acknowledged and the courtesies accepted with thanks. Carried.

On motion of Mr. B. H. Carpenter the meeting adjourned.

First Day—Evening Session.

The meeting was called to order at 8.30 o'clock P.M. by President Kent.

President Kent: The report of the tellers of election is in order.

The report was read, as follows:

REPORT OF THE TELLERS OF ELECTION.

Total ballots, 118, of which one is void on account of unpaid dues.

Report of Election:

Votes cast for John Gormly for President..........	81
Votes cast for R. P. Bolton for President..........	36

Votes cast for C. B. J. Snyder for Vice-President....	89
Votes cast for B. H. Carpenter for Vice-President...	28
Votes cast for T. J. Waters for 2d Vice-President...	61
Votes cast for W. H. Bryan for 2d Vice-President...	55
Votes cast for Wm. M. Mackay for Secretary......	107
Votes cast for Thos. Barwick for Secretary.........	9
Votes cast for U. G. Scollay for Treasurer..........	70
Votes cast for H. A. Joslin for Treasurer..........	45

For Board of Governors:

R. C. Carpenter....................	101
B. F. Stangland....................	62
James Mackay......................	80
A. B. Franklin....................	60
F. K. Chew.........................	80
H. L. Hall..........................	52
W. G. Snow.........................	51
J. H. Davis........................	37
C. R. Bishop......................	27
B. S. Harrison....................	35

The first five were elected.

Respectfully submitted,

F. G. McCann,
J. J. Wilson,
Newell P. Andrus.

President Kent: You have heard the report and the gentlemen named as receiving the highest number of votes for the several offices are elected.

The first paper is: "Heating and Ventilating the Main Auditorium of the Broadway Tabernacle," by C. Teran.

Mr. Teran read the paper, and it was discussed briefly by several members.

The next paper was entitled: "Some features of the heating and ventilating system in the Bellevue-Stratford Hotel, Philadelphia," by William G. Snow.

Mr. Snow read an abstract of the paper, and it was discussed by Messrs. Barron, Quay and Gormly.

President Kent: Mr. Cary has something to present.

Mr. Cary: I am afraid I will be unable to be here to-morrow, and as to-morrow is a day of considerable moment to all Americans, I beg leave to offer the following informal discussion:

BENJAMIN FRANKLIN'S CONTRIBUTIONS TO THE ART OF HEATING AND VENTILATION.

The American Society of Heating and Ventilating Engineers happened by some strange coincidence to hold their present annual meeting on January 17, 1906.

Two hundred years ago upon this same date Benjamin Franklin was born, and upon this bi-centennial anniversary of his birth it seems but fitting that some recognition should be given to this great man by this Society, as he was undoubtedly the originator of what has been commonly recognized as American practice in heating and ventilation.

During the eighty-four years of his busy life he loaned himself to many pursuits, including literature, politics and science, and he was widely acknowledged both at home and abroad as being a master in all of them.

The part of his scientific investigations which appeals most to us is his invention between the years 1740 and 1745 of what he called the "Pennsylvanian fireplace," which excellent design was afterwards imitated and changed, until in many cases its original form and principle were entirely lost sight of, and we find many of these so-called improvements bearing the name, even to-day, of the Franklin stove.

The fact that fuel was growing scarcer and dearer every year caused Franklin to revolt against the fearfully wasteful manner in which such fuel, principally wood, was being used, and his investigation caused him to make a careful study of all the different methods of house heating. After studying their various faults he was finally led to invent the Pennsylvanian fireplace, which resulted in great economy of fuel and in a properly heated room, such as was hardly known at that time according to the sense that we consider a room to be properly heated to-day.

The real Franklin stove was not the mere iron fireplace which masqueraded under that name, but it was an apparatus which took cold fresh air from the outside of the house and after warming it in passages kept hot by the escaping gases of the fire it was finally

discharged into the room, and this old original Franklin fireplace, if enlarged and slightly altered and placed in the cellars of our houses, certainly would become the prototype of all of our hot-air furnaces.

Franklin died on the 17th of April, 1790, and left a large amount of literary work behind him which had hitherto been unpublished, and much of this pertained to the history of his life, and this matter was bequeathed to his grandson, no doubt the intention of the testator being that the grandson would further their publication.

Shortly after the death of Franklin this grandson hastened to London, thinking that the best market for literary projects, and began negotiations with several publishers, but on account of what was considered in those days the very large price which he asked for this matter, there was considerable delay in having it accepted, and during that time the grandson suddenly withdrew these manuscripts from the market, and they disappeared and have never since been properly traced, but the writings of Dr. Franklin and references concerning his life were gathered together, and finally, twenty-six years after his death, or in 1806, just 100 years ago, these collected works in Philosophy, Politics and Morals were published in London, and as most of the matter in this book comes directly from Benjamin Franklin's pen, as does his account of the development of the real Franklin stove, and his method for ventilating rooms heated by these stoves, as well as his studies concerning the action of smoke and chimneys and his invention of a new stove for burning bituminous coal, I would suggest that as a fitting memorial by the American Society of Heating and Ventilating Engineers that the papers concerning these matters be reproduced in the *Transactions*, that the matter may be available for all of our members as well as others who have occasion to consult our *Transactions*, and as I am the fortunate possessor of this old edition of Franklin's works I would be pleased to loan it to the Secretary of the Society until the matter could be put in print with its accompanying plates of sketches and drawings.

Mr. Barron: I make a motion in accordance with Mr. Cary's suggestion, that Dr. Franklin's idea be incorporated in our next Proceedings, and that the motion be referred to the Board of Governors.

The motion was duly seconded.

Mr. Chew: I suggest we give a vote of thanks to Mr. Cary for his kind offer.

Mr. Barron: I accept that as an amendment.

A Member: Would it not be in order, if the Board decide to print this, that the style be followed as far as possible?

Mr. Cary: The type is old. There might be some difficulty, yet I believe the type exists now. The spelling is odd. I think it would be well to preserve it and take his article upon the Pennsylvanian fireplace as nearly word for word as possible and use the same spelling. I think we should do that if we wish to have this as a memorial of the bi-centennial. It is all taken directly from Dr. Franklin's pen. I don't think it should be revised or changed. The cuts accompanying it are very interesting and well executed.

The motion was agreed to.

(Dr. Franklin's paper is printed as paper No. CLIX, at page 160 of this volume.)

Mr. Gormly: I have a clipping from the "Evening Post" which calls attention to the fact of a resolution before the Board of Aldermen to appoint a commission to formulate building rules. They say nothing about the ventilating engineer, and I think something should be done by which our people will be represented. It should be called to the attention of the authorities that we should have a man representing us on that commission.

Mr. Gormly read the article.

Mr. Harvey: I move our Board of Governors be requested to place themselves in communication with Alderman Morris and call attention to the fact that matters which are quite essential to heating and ventilating should be incorporated in his bill.

The motion was seconded.

Mr. Quay: I think it is better to have a special committee, so it can be acted upon quickly before the law is passed. A committee of three should be appointed to take the matter up and do what is for the best interest of the Society, that committee of three to confer with the authorities and see that proper consideration be given to heating regulations.

Mr. Quay's suggestion was accepted as a substitute for Mr. Harvey's motion, and was agreed to.

On motion of Mr. Barron the meeting adjourned.

SECOND DAY—AFTERNOON SESSION.

The meeting was called to order at 2.35 P.M. by President Kent.

President Kent: First, is the reading of the paper, "Arrangements for the ventilation of the debating rooms of the new Riksdag's Building in Stockholm, and the results obtained in this respect," by Wilhelm Dahlgren, Stockholm, Sweden.

The paper was read by Mr. B. H. Carpenter. It was discussed by Messrs. Bolton, Barron, Donnelly, Carpenter and Wolfe.

President Kent: We will pass to the report of the Committee on Collection of Data on Furnace Heating. The Committee has prepared a series of questions and had them printed and distributed.

Mr. Chew: The questions were prepared by the President and by Mr. Oldacre. I claim little credit for that part of the work. They were printed in all the trade papers and we secured an answer from one of our members, and since then another man, outside the Society, has sent us a set of plans and a partial answer to some of the questions. I hardly think it worth while to read all the questions. I think if I read first the question and then the answer by Mr. Snow you will get a more intelligent idea of what the committee has done and what the members have done.

(Mr. Chew here read each question and the corresponding answer made by Mr. Snow, to the number of eighteen. The report and the discussion are printed as Paper No. CLVIII. at page 130 of this volume.)

You all have copies of this paper here. We have present with us Mr. J. P. Bird, who answered some of the questions, and, in the "Metal Worker" of December 16th, his answers to these questions are given, with the floor plan of the building, the pipe arrangement, and the cold air supply arrangement as he would design it. You will find Mr. Bird's answers later on in the paper. We also have an answer from Mr. R. L. Spellenburg, of Dubuque, Iowa.

On motion of Mr. Bolton the report of the committee was received with thanks, and the committee continued.

The report was discussed by Messrs. Chew, Bolton, Lyman, Snow, Berry, Kent, R. C. Carpenter, Sabin and Davis.

President Kent: This topic has been handed to me: "What is

the amount of water evaporated by one pound of fuel in actual furnace experience?" I understand this refers to house-heating boilers. As regards large boilers, any amount of information collected in the last one hundred years can be found in books. Has any one any facts?

Mr. R. C. Carpenter: I have made tests of hot-water heaters, in which I have tried to operate them in the way they would be operated in use, that is, by putting on coal once in about four hours and trying to run the heater so as to burn about four pounds of coal to the square foot of grate per hour. At other times I have tried to keep a thin fire, supplying the coal at intervals and feeding slowly so as to burn about four pounds per square foot of grate per hour. Under these conditions I have found in three cases that the economical results were good. I made a test last year which showed good results. It is my impression that the house-heating boiler is fully as economical as the large power boiler and that you can expect a return in steam heat somewhere near 70 to 75 per cent of that in the coal if anthracite coal be used. In the case of the heating boiler in the Veterinary Building the efficiency was 72 per cent. This was a plain tubular boiler of 80 horse-power.

Dr. Kitchen: All the manufacturers claim an efficiency of nine pounds of water to one pound of coal. That is about as well as most high-power tests go.

Mr. R. C. Carpenter: The results in the tests referred to showed an actual evaporation per pound of coal of 6.82 and 7.8 pounds. and an equivalent evaporation per pound of combustible of 10 and 10.6 pounds of water. I concluded from these tests that the small house-heating boiler is as economical as a big one.

After announcements by Secretary Mackay relative to the banquet to be held this evening, on motion the meeting adjourned.

Third Day—Morning Session.

The meeting was called to order at 11 o'clock A.M. by President Kent.

President Kent: The first paper is: "Power required to thread, twist and split wrought iron and mild steel pipe," by T. N. Thomson.

The paper was read in abstract by Mr. Thomson and discussed by Secretary Mackay and Messrs. Walker, Howe, Barron, Gormly, Donnelly, Quay, and Speller.

President Kent: The next paper is: "Sizes of return pipes in steam-heating apparatus," by J. A. Donnelly.

Mr. Donnelly read the paper, and it was discussed by Messrs. Barron, Harding, Bolton, and Secretary Mackay.

Third Day—Afternoon Session.

The meeting was called to order at 2.30 P.M. by President Kent.

President Kent: We will first have Mr. Donnelly's paper: "A new vapor-vacuum system of steam heating."

Mr. Donnelly read the paper.

Secretary Mackay: I would announce that Mr. Franklin P. Stoy, Mayor of Atlantic City, is present with us. He is anxious we should have our summer meeting next summer at Atlantic City. He desires to take an early train back to Atlantic City, and asks the privilege of the floor for five minutes.

Mayor Stoy addressed the meeting, describing the advantages of Atlantic City as a place for holding conventions.

President Kent: I will reply to Mayor Stoy and say that if we don't go to Atlantic City it will not be because the attractions are not great, nor because the hospitality there is not great. But duty may call us West. I will say that we have been to Atlantic City more than once. Every man who has ever been to Atlantic City, either with the meetings of this society or otherwise, keeps going there the rest of his life with his wife and family. If we don't go there next summer as a body a lot of us will go there as individuals.

Mr. Donnelly's paper was then discussed by Messrs. James Mackay, Gormly, and Barron.

President Kent: We will proceed with the next order of business, the installation of officers.

The following officers having been duly elected took the platform:

President, J. Gormly; 1st Vice-President, C. B. J. Snyder; 2d Vice-President, T. J. Waters; Secretary, W. M. Mackay; Treasurer, U. G. Scollay.

Board of Governors: R. C. Carpenter, B. F. Stangland, James Mackay, A. B. Franklin, F. K. Chew.

President Kent: Mr. Gormly, I have to congratulate you upon your election to this honorable position of President of the American Society of Heating and Ventilating Engineers. The best I can hope for you is that you will be treated in that position as I have been, and I hope you will enjoy fulfilling the duties of your office.

Mr. Mackay, if he will be as good a Secretary as he has been, that is all we can ask of him.

Mr. Scollay will take care of the funds and make up all deficiencies.

Mr. James Mackay represents the wild and woolly West, and we are glad to have him here to look after the next meeting in the West.

Mr. Chew, we are glad to have a representative of the press with us—the general press.

(President Gormly in the chair.)

President Gormly: I think at this time you would rather continue business than have any speechmaking. I will say this to you, however, I know there are a great many of our members whose minds are stored full of valuable information, and it will be our earnest endeavor to get that out of them the coming season. Some of you may be too busy to give your time to the preparation of a paper as you would like to prepare it. If you will be kind enough to send the matter to us we will make an effort to prepare it for you if you don't have the time. We will try to give it the time; because we feel it is an absolute necessity to get matter of that kind here. That is what we are associated for, and the more of it we get and the more it is discussed here the more this organization will benefit each member. (Applause.)

Next is the appointment of committees.

Compulsory Legislation: T. J. Waters, Chicago; H. D. Crane, Cincinnati; C. H. Basshor, Baltimore; A. Harvey, Detroit; W. H. Bryan, St. Louis.

Standards: Prof. Wm. Kent, Syracuse; W. F. Wolfe, Philadelphia; Prof. J. H. Kinealy, St. Louis; R. P. Bolton, New York; E. F. Capron, Chicago.

Tests: Prof. J. D. Hoffman, Lafayette, Ind.; W. G. Snow, Boston; H. A. Loeb, Philadelphia; S. G. Neiler, Chicago; C. R. Bradbury, Washington, D. C.

Special Committees: *New York Building Code:* U. G. Scollay, Brooklyn; E. Rutzler, New York; D. M. Quay, New York.

Furnace Heating Committee: Prof. Wm. Kent, Syracuse; F. K. Chew, New York; C. E. Oldacre, Philadelphia.

Mr. Chew: It is getting late, and I suggest before we take up topical discussion it would be well to discuss the summer meeting question. You have had an invitation from the Mayor of Atlantic City to-day, and I think the Milwaukee member will want to say a thing or two. Possibly somebody from Chicago would like to say something. I really believe it is more important to the Society and of more interest to the members here than to discuss the topics.

After further discussion by Messrs. Chew, James Mackay and Scollay, Mr. Chew made a motion that it is the sense of this meeting that the Board of Governors consider holding next summer's meeting in the West and that the selection of the city be left with the Board.

The motion was duly seconded and discussed by Messrs. Barron, Chew, Gombers, Quay and Davis, and was carried unanimously.

Mr. Chew: I move a committee be appointed to collect data on sizes of steam mains and returns—three from one city.

The motion was duly seconded.

Secretary Mackay: I move to amend that said committee report to the Society through the Committee on Standards.

The amendment was accepted by Mr. Chew. After considerable discussion the motion as amended was carried.

President Gormly appointed as said committee Messrs. J. A. Donnelly, H. J. Barron, and F. G. McCann.

Mr. Chew: My success with that motion inspires me to make another. I firmly believe better results can be accomplished by the appointment of special committees than through the plan we have followed the last ten years. That is the only reason why I make a motion to appoint a special committee of three to collect data on steam-heating systems for small buildings, to report in the same way, although I don't see where there is any advantage in that, for if we had had to work through the Committee on

Standards I think the Furnace Committee would have dropped the oyster and left the wharf.

The motion was duly seconded and agreed to.

President Gormly appointed as said committee Messrs. J. J. Blackmore, B. H. Carpenter, and A. M. Feldman.

Mr. Chew: In the *Real Estate Record and Guide* there is a piece which I presume few of our members have seen. I read the first paper and the second, and there are statements made which strike at our whole principle as engineers, that heating and ventilating have proven failures and the open window should be preferred for ventilation. These articles are on that line, and I presume it was to advertise some special system. I call attention to it that the members can read the issues of August 5th and 12th and September 12th and see if some action should not be taken, the articles are so much at variance with the principles of our organization. I want another committee appointed to collect data on hot-water heating. I will make a motion that the President appoint a committee to collect data on hot-water heating. I would say that the Furnace Heating Committee has some information on steam and hot-water heating we will be glad to turn over to them, and not only that, but we will be glad to explain to them the methods pursued and lend them any assistance we can; and further than that, during the year the trade press stands ready to further the efforts of any one of these committees in the work they are engaged upon. I say it for all my friends here at the press table. (Motion seconded.)

Mr. Quay: I move this matter be referred to the last committee appointed.

After some discussion Mr. Chew's motion was agreed to.

President Gormly: I will appoint on that last committee, to collect data on hot-water heating, Messrs. James Mackay, E. F. Capron and S. R. Lewis.

We will now go back to Topic No. 5: "The advantages and disadvantages attending the use of the thumb rules."

The topic was discussed by Messrs. Gerry and Kent.

President Gormly: The next topic is No. 6: "The effect of exhaust fans for ventilating rooms heated by direct radiators."

The topic was discussed by Messrs. James Mackay, Quay, and Chew.

Some discussion was had on the subject of the Publication

Committee's action in excluding from the Proceedings a paper, but no motion was made on the matter.

On motion of Mr. Chew, the meeting adjourned.

List of Members and Guests present at Twelfth Annual Meeting, January 16, 17, and 18, 1906:

MEMBERS.

Addams, Homer.
Andrus, Newell P.
Barr, George W.
Barron, Hugh J.
Barwick, Thos.
Bernhard, John B.
Berry Edw. S.
Bishop, Chas. R.
Blackmore, J. J.
Blodgett, F. P.
Bolton, R. P.
Bradbury, C. R.
Brennan, John S.
Carpenter, B. H.
Carpenter, R. C.
Carpenter, R. R. M.
Cary, A. A.
Chew, F. K.
Clark, Geo. W.
Corbett, Frank J.
Cryer, A. A.
Davis, Bert C.
Davis, Jas. H.
Denny, Edw. B.
Donnelly, Jas. A.
Doolittle, W. C. J.
Driscoll, Wm. H.
Edgar, A. C.
Faulkner, Harry C.
Febrey, E. J.
Feldman, A. M.
Franklin, Albert B.
Geiger, Aug.
Gombers, Henry B.
Goodrich, J. A.
Gormly, John.
Graham, Joseph.
Hankin, Richard.
Harrison, B. S.
Harvey, Andrew.
Hellerman, H. H.
Hoffman, G. D.
Ingalls, Fred'k D. B.
Jellett, Stewart A.
Joslin, H. A.
Kellogg, C. V.
Kent, Prof. Wm.
Klemm, J. Geo., Jr.
Lewis, S. R.
Lyman, C. M.
Mackay, Jas.
Mackay, Wm. M.
McCann, Frank G.
McKiever, Wm. H.
Morrin, Thos.
Nowell, H. W.
O'Hanlon, Geo.
Oldacre, C. E.
Osbourn, M. P.
Payne, John A.
Phillips, Lee.
Quay, D. M.
Riley, C. L.
Ritter, H. H.
Robertson, Geo. A.
Seward, P. H.
Scollay, U. G.
Shanklin, J. R.
Sherman, L. B.
Smith, H. A.
Snow, Wm. G.
Snyder, C. B. J.
Stangland, B. F.
Teran, Cesar.
Thomson, T. N.
Vrooman, Wm. C.
Washburn, Wm. S.
Welsh, H. S.
Webster, Warren.
Wilson, H. A.
Wilson, J. J.
Wing, L. J.

GUESTS.

Armitage, C. F.
Barnes, E. W.
Bird, John P.
Bloor, W.
Boylston, John.
Bradbury, F. C.
Burgess, E. L.
Butler, P. W.
Catlin, A. W.
Childs, R. T.
Collins, J. M.
Davis, W. A.
Deoher, Harry A.
Fabricius, F. H.
Fay, C. H.
Gaylord, W. H.
Greene, H. T., Jr.
Grier, Wm.
Haines, Newlin.
Harding, Jas. A.
Howard, W. H.
Howe, A. F.
Hurd, B. H.
Kaiser, Martin L.
Kiewitz, Conway.
Koithan, W. S.
Lyle, J. J.
Macon, W. W.
Marks, H. J.
Mayo, Robt., Jr.

McArthur, C. D.
Miller, C. A.
Monash, L. P.
Morrison, Chas.
Mosner, John.
Nettleton, Lloyd H.
Newkirk, W. S.
Niehl, A. H.
Old, C. W.
Olmstead, E. J.
O'Neill, A. J.
Rogers, C. W.
Sanguinette, Percy A.
Schaffer, Fred A.
Schnetz, F. F.
Schroth, A. H.
Smith, M. A.
Stangland, R. S.
Stewart, D.
Walker, H. H.
Warren, C. I.
Webber, Chas. F.
Weld, A. O.
Weld, Geo. F.
Wheeler, Louis H.

PAPERS

OF THE

TWELFTH ANNUAL MEETING,

New York, January 16, 1906.

CLII.

HEATING AND VENTILATING THE MAIN AUDITORIUM OF THE BROADWAY TABERNACLE, NEW YORK.

BY C. TERAN.

(Member of the Society.)

The heating and ventilating of a church auditorium has always been an interesting problem, for there are conditions found, and difficulties to overcome, in an auditorium of this kind that do not occur in the ordinary building; such as large glass surfaces, which are the source of cold draughts, little floor space for placing radiators, the necessity of placing radiators near seats making these seats undesirable.

In this case there was one difficulty to contend with, namely, that under the auditorium there is a Hall, which had to be left free of pipes and other objectionable features from an esthetic point of view; in other words, there is no cellar in which pipes and ducts could be placed. A space between the auditorium and the ceiling below was provided for this purpose. This space is about three feet deep, but as it is due to the depth of the girders that carry the floor its usefulness for placing pipes and ducts was limited, as can readily be understood.

After carefully considering all these points it was decided to use the blast system of heating, with mechanical exhaust and automatic temperature control for the auditorium, and direct radiators controlled by hand for the vestibules.

The blast system was considered the best in this particular case for the following reasons:

First—Low cost of installation.

Second—The objectionable radiators are done away with.

Third—From a sanitary point of view the fact that the place cannot be heated without at the same time ventilating it.

Fourth—Even distribution of heat.

The seating capacity of this auditorium is 1,500. The apparatus was designed to supply 25 cubic feet of air a minute per person to 1,600 persons, or a total of 40,000 cubic feet of air a minute.

It may be mentioned that in this case 25 cubic feet a minute per person was about the maximum amount of air that could be introduced without causing drafts and noise, and this by introducing a large proportion of the air through top inlets. The entire use of bottom inlets would have been impossible without causing drafts, or considerably reducing the amount of air supplied.

A three-quarter housed centrifugal fan is used to supply the air. This fan has a blast wheel 9 feet in diameter by 4½ feet wide, and is driven by a direct connected motor. The fan is calculated to deliver 40,000 cubic feet of air a minute at 130 revolutions per minute.

The heat transmitted through walls, windows, etc., was calculated to be 340,000 B. T. U. per hour, with 70° F. difference between the inside and outside temperature. Given these conditions, the incoming air would have to be heated to 78° F. to supply this loss.

This is accomplished by drawing the air through a heating stack consisting of ten two-row sections, or coils, of the mitre type. These coils are built in staggered rows of 1-inch pipe, and the stack contains 7,500 lineal feet.

The air is taken from a court at the ground level, and for this reason the intake was made large, to insure a low velocity of the air in the immediate outside vicinity. This opening is fitted with a wire screen and louver damper. Through this opening the air is directly admitted to the filter room.

The filter is of the "V" type, made of galvanized iron, with removable wooden frames, covered with wire and cheesecloth in the usual manner. The filtering area is proportioned to allow 32 cubic feet of air a minute to pass through every square foot of filtering material.

From the filter room the air is induced through the heating stack into the fan, then discharged by this into the distributing ducts and flues, leading to the auditorium.

The velocity of the air is reduced in the ducts to 1,900 feet a minute, and in the flues to 900, and finally discharged at 600

through the top registers and 200 through the floor registers.

The heat registers are placed from 8 to 12 feet above the main auditorium and gallery floors.

There are also heat registers in the floor in front of the large windows, and in the step risers of the front gallery.

The air discharged by the registers in front of windows is intended to counteract the cold air drafts produced by these cooling surfaces.

A large proportion of the air is introduced on the same side as the pulpit, so that its travel is in the same direction as the voice of the speaker, thus aiding, or at least not interfering with the acoustics of the Auditorium.

The equal distribution of the air is obtained to a large extent by the location of the exhaust openings.

Each pew end on the main floor has an opening near the floor, forming part of the design of the ends of the pews, these openings are connected with the space underneath the auditorium before referred to, which is also used as an exhaust chamber.

The connections between this chamber and the openings in the pew ends are made by cast-iron hoods, placed against the inside of the pew ends, and covering both the opening in the pew end and that in the floor leading to the exhaust chamber. These hoods are provided with controlling dampers, to regulate the flow of air through them.

The exhaust chamber is connected at one end to a Blackman exhaust fan 6 feet in diameter. This fan is driven by a direct connected motor and discharges into the open air. It is intended that when this fan is revolving at 300 R. P. M. it will exhaust 32,000 cubic feet of air a minute, or 80 per cent. of the amount supplied by the blower.

When the apparatus is started in operation the air is introduced at as high a temperature as the heater coil will heat it, until the temperature in the Auditorium has reached the maximum required, then the air is introduced tempered only until the temperature in the Auditorium falls below the normal, when the air is again heated to a higher temperature to supply the loss.

This is accomplished automatically by thermo-pneumatic control, as follows:

Three sections of the heating stack have separate steam connections and are controlled by a thermostat placed in the cold air chamber. This thermostat is set to operate at a temperature a few degrees above freezing, about 40 degrees Fahrenheit.

The rest of the heating stack is controlled by two thermostats, one placed in the Auditorium and set to operate at 65° F., and the other in the main warm air duct, also set to operate at 65° F. Both of these thermostats operate the same set of valves, controlling the inner seven sections of the heating stack.

The thermostat in the duct, however, is so connected that it can only act when that in the Auditorium has operated to shut off heat, during which period of time the duct thermostat will maintain the air at the temperature at which it has been set. By this arrangement the same stack is alternately used as a heating and tempering coil.

In this, as in all other Auditoriums, the heating apparatus is shut down until a short time before the audience is admitted. On this account there is a decided advantage in having the tempering and heating coils combined in one, for when heat is turned on, the whole stack is active until the required temperature is attained in the Auditorium. This makes the period of heating up shorter than it would be if the tempering and heating coils were separate.

The apparatus has been in operation for some months, and although weather conditions have not been favorable for an exhaustive test, the tests that have been made show that it gives the desired results.

DISCUSSION.

President Kent: In heating up this building, was not the air exhaust pipe stopped or closed and the air circulated round and round?

Mr. Teran: No, sir.

President Kent: Did you discharge the hot air out of the building during the time you were heating it?

Mr. Teran: We found the best way was to run the exhaust at the same time the air was blown in because the hot air would not stay down. The hot air will naturally rise, and it will take a much longer time to heat the lower part.

President Kent: You could turn the exhaust pipe and make

connections with it into the inlet pipes and make the circulation round and round.

Mr. Teran: That could be done, but there would be the temptation to do it after the audience is seated.

President Kent: How long would it take to heat that building on a very cold night, say, down to zero?

Mr. Teran: We have not had any occasion of that kind yet. That is very cold weather, but with the temperature outside not very cold it does not take longer than one-half hour.

Mr. B. H. Carpenter: What proportion of air was introduced from the front of the stage or pulpit, and what proportion from the seats?

Mr. Teran: I hardly think I could give you the exact proportion, but from the number of registers I should think not more than 50 per cent. from the side of the pulpit. There is more air introduced from the side of the pulpit than from any other side.

Mr. Barron: I think it is accepted that the floor registers are objectionable in an otherwise very good design.

Mr. Teran: The floor registers used were placed in front of very large windows to counteract this large surface draft. The velocity is very low, and as they are in the aisles back of the seats, the air does not come directly against the people there. There are some registers which are placed in the front gallery, on the riser of the steps. These are objectionable, but there was no other place to locate them.

Mr. Driscoll: The author speaks of exhaustive tests. Does this include the temperature of the incoming volumes of air, etc.?

Mr. Teran: We have not made exhaustive tests. Preliminary tests were made to adjust the velocities, and they are now about what they were figured to be. I could not tell you at what temperature the air comes in. It varies, of course, with the outside temperature. The temperature of the church is controlled by a thermostat set at 65 degrees, I think. We made some tests on account of trouble with drafts, and found where the trouble was.

Mr. Franklin: In reference to the proportion of air in these different inlets, the author says: " The heat registers are placed from eight to twelve feet above the main auditorium and gallery floors." About what proportion of the air is admitted to the room either on the eight-foot level or the twelve-foot level?

Mr. Teran: We have no proportion of distribution except that

we tried to introduce as much of the air as possible from the side of the pulpit and the rest wherever there is a cooling surface. The distribution is done more by the exhaust than by the incoming air.

Mr. J. A. Harding: With reference to the exhaust on the main floor, about what proportion of the entire area of the auditorium is provided with this exhaust? Is air exhausted from the entire area of the floor?

Mr. Teran: These exhaust openings are at the ends of the seats. There are two aisles the same as in this room, and, therefore, the distribution is nearly over the entire floor.

Mr. Harding: Does the exhaust cover all the centre portions of the auditorium or only the aisles?

Mr. Teran: The aisles.

President Kent: Is there a down current from the big window or an up current?

Mr. Teran: There is an up current.

President Kent: What becomes of the other 20 per cent. that is not taken care of by the exhaust?

Mr. Teran: Leakage takes care of that.

Mr. Barron: There is a portion of the author's paper that really presents something new in regard to automatic regulation. "When the apparatus is started in operation the air is introduced at as high a temperature as the heater coil will heat it, until the temperature in the auditorium has reached the maximum required, then the air is introduced, tempered only until the temperature in the auditorium falls below the normal, when the air is again heated to a higher temperature to supply the loss." As I understand it, he uses the heater as a tempering coil for the preliminary heating of the building, and as soon as the building is warm the thermostats close. It is something new to me.

Mr. Teran: This is not particularly new except probably as applied to churches. In other buildings it has been done.

President Kent: I think we should have a diagram and sketch showing the work of the thermostats so it could be better understood.

(The author drew a rough sketch of the thermostatic arrangement and explained its working therefrom.)

President Kent: If the auditorium gets hot will the thermostat itself shut off the steam?

Mr. Teran: The auditorium's thermostat regulates the flow of steam. It lets the compressed air through and shuts off the steam. As soon as that valve is closed and the air in the duct cools to 65 degrees the thermostat in the main duct will open the valve and permit the steam to flow again.

Mr. Harris: Wherein is the point of advantage in having this thermostat control on the main coil and admitting steam to all coils at once and shutting it off all at once, rather than dividing the coil up and controlling the tempering coils by sections? Suppose you divide the coil into sections, then you would have a certain temperature in your hot-air chamber, the mixing dampers being controlled by thermostats in the auditorium. What is the special advantage in the system adopted rather than that of mixing dampers?

Mr. Teran: The objection to mixing dampers is that the air does not get well mixed. It is also cheaper to arrange it the way we have done.

Mr. Harris: Is it not one of the objections to the mixing damper, with your system of control, that the damper must be in one position or the other, and when there is cold air you get too much cold air, and so deliver air into the auditorium at a low temperature, possibly as low as the tempering coil allows it? But, if you had a mixing damper that would give the exact position desired, would not that be preferable to this?

Mr. Teran: By this system tempered air is admitted. When the auditorium is too warm and it has to be cooled or no more heat introduced, the mixing damper is not desirable as it will let in air below the temperature of the auditorium. Sometimes when the outside temperature is mild it is difficult to keep the temperature down—in fact, it is impossible. With this system you do not shut off the heat entirely, which the mixing damper will do in such a case, but put in tempered air.

Mr. Driscoll: The thermostat operates at 65 degrees. It seems to me the temperature in the warm air duct would be 65 and the temperature of the auditorium would not go above that at any time.

Mr. Teran: It does when the outside temperature is very mild. The heat given out by the audience will make it too warm and very unpleasant.

CLIII.

SOME FEATURES OF THE HEATING AND VENTILATING SYSTEM IN THE BELLEVUE-STRATFORD HOTEL, PHILADELPHIA.

BY WM. G. SNOW.

(Member of the Society.)

Certain features or details of the heating and ventilating system installed in the Bellevue-Stratford Hotel are, it is believed, of sufficient interest to warrant the presentation of this paper.

The building itself is of considerable magnitude, having a frontage of about 185 feet, a depth of approximately 183 feet, and containing eighteen floors besides basement and sub-basement.

When the extension is built to its full height the building will contain 827 bedrooms, 566 bathrooms, and the total cubic contents of the twenty floors will exceed 6,000,000 cubic feet.

There will be in round numbers 67,000 square feet of cast-iron direct radiation and 14,000 lineal feet of 1-inch pipe in heaters.

Five 300 H.-P. water tube boilers equipped with automatic stokers furnish steam at about 125 lbs. pressure to a 12-inch loop extending across the boiler fronts and around the engine room, as shown in Fig. 1. Two valves were placed in each boiler connection to provide for safely testing the boilers by water pressure while full steam pressure is on the main header or drum connecting them. Standard pipe and extra heavy flanged fittings were installed for all high pressure work. An extra heavy ribbed by-pass gate valve was inserted in the main between branch connections to boilers, engines or pumps, these branches being connected at the top of crosses, the bottom outlet having a drip leading to a steam loop system for returning the high pressure drips to the boilers without the use of pumps or traps.

By means of the above described arrangement of valves and piping any unit can be temporarily cut out without interfering with the operation of other parts of the system.

The exhaust steam used for heating is first passed through a combined muffler tank and separator with by-pass, and is dis-

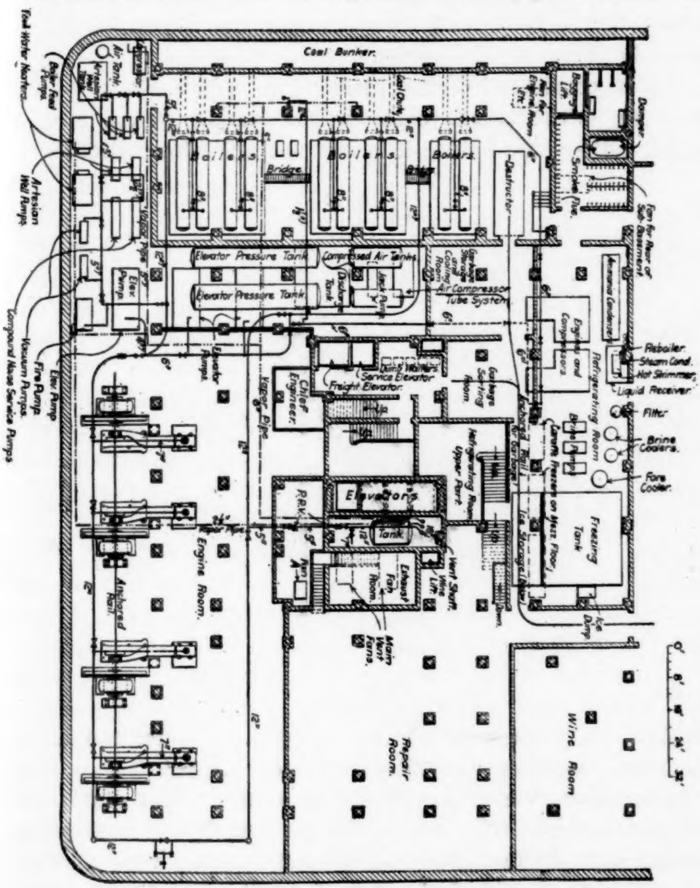


FIG. 1.

charged through an 18-inch riser. Owing to the great height and weight of this pipe extra heavy fittings were used at the bottom to safely support the load. The back pressure valve located just below the exhaust head is fitted with a by-pass to provide for overhauling it without shutting down the plant.

Practically all apparatus was installed in duplicate, each unit being large enough for the entire system.

Live steam, when necessary, is admitted to the exhaust main supplying the heating system through two reducing valves set tandem, one of high pressure pattern and the other of vacuum pressure pattern, so called, having an outlet about twice the diameter of the inlet.

It was considered better practice to reduce the pressure from that in the boilers to that in the heating system by two stages, rather than reduce it in one operation from about 125

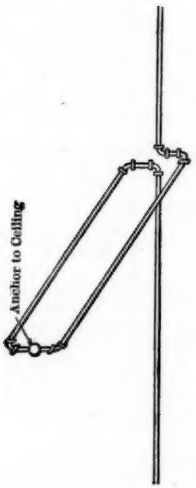


FIG. 2.

pounds to a pressure of a pound or less. A better control is thereby secured and the valves will wear longer.

In arranging the steam distributing system it was considered advisable to feed all floors above the first by the down-feed system and all floors below that with up-feed risers. This arrangement permitted the use of small pipes through the lower floors, on which, in buildings of this character, the rooms and windows are large, leaving but few partitions or wall spaces in which pipes may be concealed.

Much of the expansion of the risers is taken up in the attic, where all branches to risers are arranged with properly placed nipples and elbows to provide swing joints.

The risers are anchored at two points and contain two expansion joints or swivels of the type illustrated in Fig. 2. Ample space was provided in which to conceal these joints, owing to the fact that in this building the distance from ceiling to floor in each case is about two feet, the ceiling being suspended some distance below the fireproof floors. In the case of only one riser was it necessary to use expansion joints of the packed type. Access to these joints is provided through doors. There was no difficulty in concealing the risers, as space was provided in the building construction between the inner and outer walls.

Care was taken in making radiator connections to provide for expansion by means of a sufficient number of nipples and elbows, so arranged that no strain would come on the fittings.

In nearly all cases it was possible to set the radiators below the window sills. The top of the mahogany enclosure was made to lift on hinges; the front, running in grooves, can be lifted out.

All woodwork in connection with these enclosures was protected with asbestos air cell covering ½-inch thick covered with galvanized iron, screwed on. Asbestos covering was nailed to the brick work at the back of these enclosures and a hard coating of plaster applied to make a smooth finish.

The inlet to each radiator was through a register face of mouse-proof pattern proportioned on the basis of 2½ square inches of net area per square foot of radiation. The outlets in the top of the enclosures were of plain lattice pattern based on an area of 3 square inches per square foot of radiation.

All radiation was worked out on a wall and glass basis, due allowance being made for the cubic contents. This method gave ratios of about 1 to 50, 60 and 70 respectively for rooms on the north, east and south. Northwest corner rooms figured about 1 : 35, northeast rooms 1 : 40, and bathrooms about 1 : 30 to 1 : 35. In large rooms like the main dining-room, located at the southeast corner of the building and containing approximately 95,000 cubic feet, the ratio is 1 : 82 for concealed direct radiation. In this room, which is 20 feet in the clear, the glass is 45 per cent. of the total exposure. The windows are double.

In the Palm Garden, exposed toward the west and containing 77,000 cubic feet, direct-indirect radiators are used, connected with the blower system. Here a ratio of 1 : 148 gives

satisfactory results, the ratio of glass surface to exposure being about the same as in the main dining-room. The ratios throughout were used merely as a rough check on the amount of radiation computed on the wall and glass basis.

Owing to the fact that the direct radiators were concealed it was assumed that they would give off only 175 heat units in place of the usual allowance of 250 H. U. per square foot per hour.

On the lower floors, up to the sixth, two sets of double hung windows are used to shut out noise and dust; thus permitting the use of a smaller amount of radiation than usual in proportion to the contents, the transmission loss through these windows being taken as three-fifths the amount through single windows.

To permit the control of room temperatures by guests to suit their wishes, a long stem supply valve was used on each radiator, the wheel coming just outside the enclosure. A special valve permitting the escape of air and water but closing against steam was used at the return end of each radiator, the return mains leading to vacuum pumps in the sub-basement.

At the entrances to the building Van Kannell revolving doors are used, over which coils are placed, admitting cold air from the street and discharging it through openings overhead.

While it would have been preferable to introduce the heat near the floor at these points, it was impossible to secure suitable radiator locations owing to the decorations or to the arrangement of furniture.

By installing a sufficient amount of surface in the manner described, it has been possible to keep the corridors perfectly comfortable.

Thermostatic control of the diaphragm valves on the radiators was applied in the principal rooms. The temperature of the air supplied was controlled in a similar manner by cold air and warm air thermostats placed in the ducts controlling diaphragm valves on the heaters. A supplementary heater connected with the buffet was independently controlled by a thermostat placed in the room. Thermostats were used of a type that cannot be tampered with without unscrewing the face.

The heating of the principal rooms was treated independ-

ently from the ventilation, with the exception of the buffet in the basement.

The greater portion of this room is below the street level. The exposure is so small that it was deemed better to heat it by means of a supplementary coil placed in the sub-basement designed to re-heat the air supply than to heat the room by direct radiation. This method of heating the buffet was the simplest and least expensive, a re-heater of 300 square feet of surface serving to heat the room containing 82,000 cubic feet.

In the café and some other important rooms the fresh air is admitted through flue radiators placed under the windows, this arrangement giving a better distribution of air than could be secured with flues located in the only spaces available.

In the main and the private dining-rooms the heating is done entirely by direct radiation, the air being supplied at 70 degrees temperature through openings in the walls about 10 or 12 feet from the floor.

The rooms on the main and first floors are approximately 20 feet and 17 feet in the clear respectively, the fresh air inlets being located a little higher than usual to suit the decorations.

In the ventilation of rooms, the outlets are located near the floor, except in rooms where smoking takes place. In these they are placed in the ceiling, the openings being concealed by rosettes or stucco work incorporated in the scheme of decoration, making a very effective system and avoiding the use of wall registers.

The air supply in such rooms is, as a rule, brought in through flue radiators located below windows, this system of upward ventilation removing smoke at once from the breathing plane.

In most cases the galvanized iron air supply and vent ducts were placed above corridor ceilings, the sizes being based on velocities of 700 and 600 feet per minute, respectively, with somewhat lower velocities at the extreme ends.

Register sizes were based on a velocity of approximately 400 feet per minute through them.

The change of air in buffet, café and rooms where smoking takes place is approximately once in ten minutes. The air change in the main dining-room is once in fifteen minutes.

In certain rooms used sometimes for banquets and at other

times for readings and entertainments, top and bottom ventilating openings were provided so that the air can be withdrawn from near the ceiling or the floor, as desired.

Perhaps the most interesting feature described in this paper is the unusual location of the supply fans which, contrary to common practice, are located in the attic.

Reasons which led to this choice were lack of suitable space in the basement or sub-basement for these fans and the fact that, by locating them at the top of the shafts instead of at the bottom, branch supply ducts could be taken from the main shafts, which are gradually reduced in size, making them smallest on the lower floors where space is most valuable. The separate set of up-discharge flues necessary when supply fans are located in the basement is avoided.

The air is taken from points just above the roof and passed through ordinary cheesecloth filtering screens. Except for particles of soot the air at this high level is practically free from dust. These fans, which are of the centrifugal type, 7 feet diameter, with housings 4 ft. wide, are driven by direct connected 25 H.-P. motors at a speed of 220 revolutions per minute, corresponding to $\frac{3}{4}$ oz. pressure per square inch over an area within their capacity, forcing the air down vertical shafts a distance of over 250 feet to the rooms on the lower floors. These shafts were carefully plastered on the inside with Portland cement smoothly finished, making them as nearly air tight as possible, because with the great length the leakage would be considerable unless carefully guarded against. The air was tempered by steam coils before passing through the fans.

It was found during the most severe winter weather that no trouble was experienced in forcing an adequate volume of tempered air down the shafts, although, had it been possible to so arrange the system, the tempering coils would have been placed at the foot of the shafts instead of in the attic, thus permitting the forcing of cold air down these flues, which could have been done with much less resistance than in the case of warm air. These fans delivered in winter weather approximately 70 per cent. as much air as they would be rated to do when connected with an ordinary system of horizontal ducts.

While an air supply secured by fans located in the attic or on the roof is not uncommon with low buildings, I am not

aware that it has been successfully applied elsewhere in buildings as high as the one described.

To prevent the transmission of sound the fans and attached motors were mounted on compressed cork $1\frac{1}{2}$ inches thick, with the result that no trouble from noise was experienced in the sleeping rooms on the floor below them.

A separate fan delivering cold air to the boiler and engine room was installed, discharging through ducts with branch outlets turned down to blow directly toward the floor.

The removal of air from these rooms takes place through the boilers themselves and through the main ventilating fans.

The kitchen has its separate air supply designed to furnish tempered air forced down through outlets placed at intervals around the range, the exhaust ventilation from the range hood taking place through a steel plate flue carried independently to the roof, a steam jet being introduced to provide for extinguishing fires which occasionally occur in this flue.

The general ventilation of the kitchen is accomplished by main exhaust fans in the sub-basement and by ducts leading to the space around the steel plate smoke stack. No air is supplied other than that around the range, it being desired to maintain a slight vacuum condition in this room so that all leakage through doors and openings will be inward.

The exhaust ventilation of the principal rooms is effected by two 7 ft. $\times$ 4 ft. centrifugal fans driven by direct-connected 20 H.-P. motors run at a speed of 220 R. P. M. located in a room in the sub-basement.

Ducts lead from this suction chamber to rooms in the basement and on the main and first floors, some of the air being drawn down a vertical distance of about 75 feet, besides traveling a distance horizontally of 240 feet.

The public toilet room is connected with a separate ventilating fan of the blower type.

Fireplaces, of which there are 297 throughout the building, are connected with three 90-inch centrifugal fans located in the attic. They are designed to run at a speed of 320 revolutions per minute and are driven by $7\frac{1}{2}$ H.-P. direct-connected motors.

All water closets in bathrooms have a 2-inch local vent connected with pipes leading to 70-inch exhaust fans of the blower type placed in the attic. Three of these fans are used to re-

move the air from 566 bathrooms. They are run at a higher speed than any others in the building, owing to the small size and great length of the pipes connected with them. They are driven by 6 H.-P. direct-connected motors at a speed of 470 revolutions per minute.

The ballroom, containing about 250,000 cubic feet, is heated by direct radiation and has a separate system of ventilation, so that it can be used independently of any other part of the building.

Two 90-inch fans were provided, to be located in the attic with tempering coils for forcing down the supply of fresh air to registers located around three walls of the room below the balcony. It was impossible to introduce flues on the exposed side of the room, owing to space taken by windows.

Ventilation takes place through ceiling openings connected with an extensive system of ducts leading to two 4-foot exhaust fans of the propeller type, driven by direct-connected electric motors.

The ballroom system was designed to change the air once in ten minutes.

The heating of the water supply is an important item in a building of the size and character of the Bellevue-Stratford Hotel, and comes under the general title of this paper. Two 1,000-gallon hot water generators were used, the cold water supply to these first passing through coils in the drip tanks.

Either exhaust or live steam can be used in these generators, two thermostats being suppied to control the admission of steam. The one for live steam is set at a little lower temperature than the one for exhaust, so that in case the supply of exhaust steam is insufficient to give the desired temperature, live steam is supplied at a reduced pressure of 15 pounds.

When steam at this pressure is admitted, it closes a swing check valve on the exhaust steam supply line until the temperature of the water rises to a point where live steam is no longer needed.

These generators are located some distance above the feed water heaters to which the drips are trapped.

DISCUSSION.

President Kent: What is the use of these 297 fireplaces?

Mr. Snow: This is a high-priced hotel and a great many people want a gas log. They give the guests anything they want if they pay the price. Among other things they provide for the removing of the smoke from large fireplaces in the main lobby, where they burn four-foot logs.

President Kent: Can you explain how these revolving doors can take in cold air and deliver it as warm air?

Mr. Snow: These are circular doors of the Van Kannell pattern, and the admitting of air above them has nothing to do with the operation of the doors. In a building of this character it is difficult to find space for anything, and by placing the radiation over these doors we avoid interfering with the decorations or arrangement of furniture.

President Kent: The door still gives a supply of cold air?

Mr. Snow: Lack of available space prevented the placing of radiation on the floors where it would be most effective. I have never seen radiation placed above the doors before, but it has worked out successfully.

Mr. Barwick: Do you get the fresh air through the ceiling of the Van Kannell door?

Mr. Snow: From the outside through the registers provided above the top of these doors.

Mr. Barron: About direct connected motors. We all know direct connected motors with a large fan cost more money than a high-speed belted motor. I want Mr. Snow's opinion on direct connected motors on large fans, as he mentions in this building.

Mr. Snow: On general principles it is much more satisfactory to use the belted motor, for all you have to do if there is difficulty about the air supply is to change the size of the fan pulley. On the other hand, there is more or less belt slippage and attention required; and another point we all appreciate in attempting to lay out work of this character is lack of space to get any reasonable distance for belts. With direct connections the calculations have to be right at the outset or it means a new motor.

Mr. Barron: Does Mr. Snow think on the whole the belted motor is not such a bad thing where you have room to belt it?

We didn't have much trouble thirty years ago, but with the modern engineer it is awfully dangerous, for most of them wouldn't know how to lace a belt if they tried.

Mr. Snow: Where you have one fan or two fans in a church, school building or public building that is a different proposition from where you have twenty odd fans as we have in this building. There the attention required by twenty belted motors would be considerably in excess of that required by twenty direct connected ones.

Mr. Quay: Where you can get space for a proper distance for a belt there is a gain where you have to carry the fan on a steel structure. Direct connected motors are larger and heavier and take a great deal more space. It takes special framing for additional weight, if they are a great deal larger.

Mr. Snow: In the case of this building we had four 7-foot fans, one 6-foot fan and several other fair sized ones, all equipped with direct connected motors. In the case of only one of the large fans would we have had space for a belted rig.

Mr. R. R. M. Carpenter: Do you mean you place two valves on each boiler connection, and, if so, why was it done?

Mr. Snow: For the purpose of testing; that is all. There was a drip valve between the two. It gives double protection.

President Kent: Was any allowance made for cubical contents in working out the radiation?

Mr. Snow: The reason I expressed it as I did was, I have a rule of my own which I have used for several years successfully. To the heat lost by transmission I add, in rooms with one exposure, a number of heat units equal to the cubical contents multiplied by $\frac{1}{4}$. And for corner rooms I add to the transmission loss a number of heat units equal to the cubical contents divided by three.

Mr. Gormly: Five hundred and sixty-six bath-rooms. As a criticism on this job I would like to have expression whether it is not considered dangerous to take air from a roof where there are 566 closets discharging foul air. What are the figures relative to hot water?

Mr. Snow: This hotel is 185 ft. front and 183 ft. in the other direction, and you have to take air from somewhere. The purest air comes from the vicinity of the roof. We endeavored to keep, and always do, the level of the intake below that of the smoke

outlet or from the outlets from toilet vents, the discharge from which takes place at a high velocity, carrying the smoke and foul air up into the outside air. The intakes are at a lower level, so there is very little likelihood of the fresh air supply being contaminated.

In regard to the capacity of the hot-water generators, in this particular case I shall plead not guilty. The hot-water generators were furnished by the plumber, but, as in many cases of this kind, the heating engineer provided for the steam supply and drip connections.

Mr. Quay: The figures of the additional power required to force the warm air down from the attic to the rooms are interesting. I want to ask Mr. Snow if he has any figures relative to the upward tendency of the air in the shaft.

Mr. Snow: I haven't any figures here, but I will state for your satisfaction that we did not have to make any changes whatever in the arrangement. It gave the required amount of air as we expected it would. With a speed of 220 revolutions one of the 7-foot fans with a direct connected 25 horse-power motor delivered 30,000 cu. ft. of air per minute, and when tested we found we had 10 per cent. to 20 per cent. leeway in power. The 7-foot vent fans in the basement have 20 horse-power motors each, and they worked all right at 220 revolutions, discharging into a shaft 300 feet high.

CLIV.

ARRANGEMENTS FOR THE VENTILATION OF THE DEBATING-ROOMS OF THE NEW RIKSDAG'S BUILDING IN STOCKHOLM, AND THE RESULTS OBTAINED IN THIS RESPECT.

BY WILHELM DAHLGREN, STOCKHOLM, SWEDEN.

(Member of the Society.)

The object of the following paper is to contribute to the solution of a ventilating question which has been and is the subject of much debate. This question is: In a meeting room with fixed seats—such as the auditoriums of theaters, concert-rooms, debating-rooms, and the like—is it best to introduce fresh air near the floor and carry off the vitiated air near or at the ceiling, or vice versa.

A new Riksdag's (Parliament) Building has just been built in Stockholm, which has been in use for one winter—and one summer—session. The above-named question had already been broached when the ventilating-system for this house was planned, some ten years ago, but was then one of greater uncertainty than it is now. The resolution was, therefore, come to, to employ a double system, *i. e.,* to make it possible for the fresh air to pass from below upwards, and also from above downwards. Both systems were to receive equal justice, and were to be treated with equal care, and experience was to decide which of the two systems was the more satisfactory.

The Swedish Riksdag consists of two chambers. The First Chamber consists, from the method of election, of persons belonging to the higher and wealthier classes, and, it may be said, of persons who are much past middle age. The Second Chamber is elected by "popular" vote; its members consist, only in a small degree, of persons of the same class as those in the First Chamber, the majority being peasants, tradesmen, and workmen. This state of things is of no small importance for the right understand-

ing of the circumstances which exist in connection with the question of the system of ventilation.

Both Chambers have perfectly similar debating-rooms, with but that difference which is necessitated by the fact that the members of the First Chamber number 150, and those of the Second Chamber 230. The areas of the two floors, then, are in proportion to these figures, as the Debating-Rooms are constructed for a corresponding number of seats. The rooms are octagonal in shape, with the highest part circular in form, and have, on seven

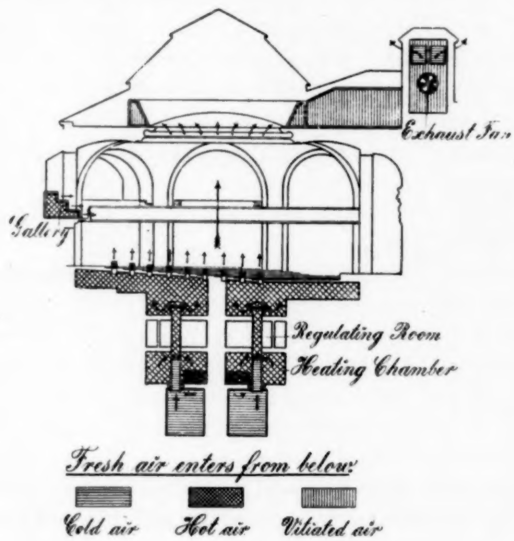


FIG. 1.

sides, galleries for the accommodation of the public. The seats for the members of the Riksdag are placed in pairs with aisles on each side. The floors slope from the sides of the floor down towards the tables provided for the Speaker and the Clerks. The rooms are lighted from the roof. The space between the inner and the outer glass roof is warmed, so that no cold can strike downwards from the roof. The Debating-Rooms are surrounded on six sides by warm rooms or other premises. The two remaining outer walls are hollow-built and are warmed by means of circulating air (quite shut out from communication with the Debating-Room). The Debating-Rooms thus have no transmis-

sion of heat in any direction that could cause drafts in consequence of cold currents of air. The accompanying figures give a schematic representation of the arrangement and employment of the one or the other of the two systems of ventilation.

Fig. 1. *Upward Ventilation.* The fresh, and, usually, warmed air, is driven upwards by a propulsion fan, from the lowest duct marked on the drawing, to a hot-air chamber lying above it. Above the hot-air chamber lies a regulating room where every-

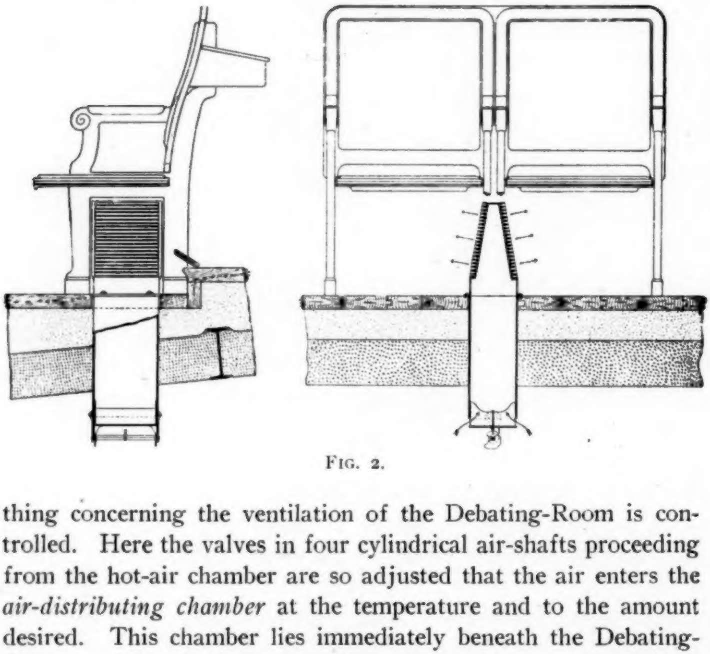


FIG. 2.

thing concerning the ventilation of the Debating-Room is controlled. Here the valves in four cylindrical air-shafts proceeding from the hot-air chamber are so adjusted that the air enters the *air-distributing chamber* at the temperature and to the amount desired. This chamber lies immediately beneath the Debating-Room, and is of the same surface-area as the area of the floor above. For each pair of chairs there is an air-flue in the floor as shown in Fig. 2.

The flue is provided at the bottom with a valve which can be regulated or entirely closed, and in this way the ventilation can, to a certain degree, be regulated so as to suit the individual demands of each Member of the House. In order that the air shall stream into the room at the least possible speed, cast-iron gratings with exteriorly widening orifices are employed. Experiments have shown that the air streams out almost exactly equal over

the whole surface of the grating, and that the jets of air from the individual openings unite again fairly well. Were the movement of the air quite homogeneous, the maximum speed at full ventilation would amount to but 0.25 meter = 10 inches per second. It is a specially favorable circumstance that, as we have already mentioned, the Members of the Riksdag sit in couples. This makes it possible to direct the stream of air to both sides outwards into the aisles between the rows of chairs. The air-current that actually exists, although it is but a very weak one, is, therefore, not directed forwards against the legs of those seated in the room, as is usually the case. As the gratings do not lie in the same plane as the floor, but are almost vertical and elevated above it, this does away with the usual objection, that the current of air blows the dust about. The arrangement of the gratings has, most certainly, a great deal to do with the good results that have been obtained. The vitiated air is led off by way of the ceiling. The outlets for the air build a narrow opening along the entire ceiling-circle and are only broken by the spaces needed for the beams carrying the ceiling. The vitiated air streams out into a practically circular duct and moves along this to an exhaust-fan which forces the air out into the open. The speed, both of the electric exhaust-fan and of the propulsion-fan, can be controlled from the regulating room. By means of a *pneumometer,* an instrument for measuring small differences of pressure, constructed by G. A. Schultze, of Berlin, it can be observed in the regulating-room if there is more or less pressure in the Debating-Room than in the surrounding rooms, passages, etc. This exceedingly sensitive apparatus shows a difference of pressure measurable by $\frac{1}{40}$ mm. of a water-column. With the assistance of this valuable instrument, it is easy to control the work of the two fans in respect to each other so that a very slight degree of higher pressure prevails in the Debating-Room than in the surrounding rooms. This is of especial importance as preventing drafts from the doors.

To the galleries air is led from below, although in a simpler manner than that adopted on the floor of the room.

The measuring instruments employed and observed in the regulating room are, in addition to the pneumometer already named, a static anemometer (air-meter) in each of the four cylindrical main shafts and pneumatic long-distance thermometers that give the temperature in the Debating-Room and in the galleries, etc.

The anemometers are made in the form of sensitive balances, one scale of which hangs in the air-current and brings about a greater or less movement of the balance.

Fig. 3. *Downward Ventilation.* The fresh air enters, as in the former case, by means of the propulsion fan from the lowest duct marked on the drawing, but it is afterwards carried vertically upwards into a walled hot-air chamber beneath the roof. Its steam-valve is controlled from the regulating room, but there are in addition two large mixing-valves for cold and warm air, which

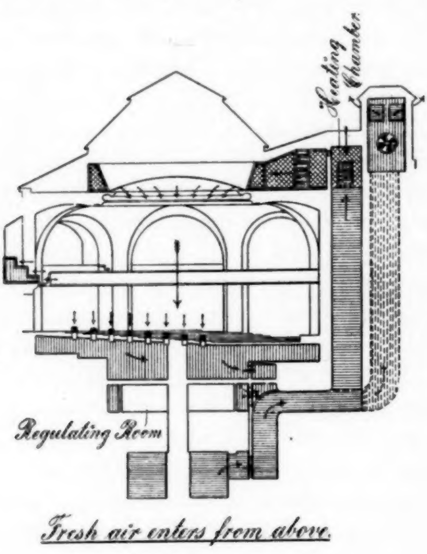


FIG. 3.

valves are also controlled from the regulating room. The air, which is adjusted precisely by these valves, both as regards quantity and temperature, now enters the circular duct before mentioned that communicates with the Debating-Room by means of the narrow opening around the ceiling of the room. The outlet expands inwards towards the room in order that the speed of the air shall be reduced on its streaming in. The vitiated air is now taken through the same gratings beneath the seats which previously formed the inlets, and thence comes into the chamber beneath the room. From this chamber a vertical shaft, shown by dotted lines, leads up to the same exhaust-fan that served for

carrying off the vitiated air in the former case. From the different rows of the galleries the vitiated air is also carried off through the same openings that formerly allowed the fresh air to stream in, and the vitiated air is carried downwards to the same shaft that serves for the ground floor of the Debating-Room. In this system, too, special distance-thermometers and anemometers and pneumometers are also employed, so that both systems are equally complete in every respect.

When the Debating-Rooms were first occupied, the air in the one room was allowed to go upward, and in the other room downward, while nobody was informed that any difference in systems existed, or of the direction in which the air went. At first only short meetings were held, and it seemed as if the two systems could be used indifferently, no complaints being made. But things changed when long sessions lasting many hours began to be held. In the Debating-Room where, for the occasion, downward ventilation was being employed, a general uneasiness and complaints arose in consequence of the drafts. But when upward ventilation was employed, nothing was heard any more. This experience was gained both in the First and Second Chambers, although it was at different times that downward ventilation was employed in the one or the other room and without anyone being informed of the matter. The result was that in both Debating-Rooms all attempts to use downward ventilation were abandoned, so that at present nothing but upward ventilation is employed.

But the experience gained in the Debating-Rooms of the First and of the Second Chambers presents, however, decided differences. In the Second Chamber no inconvenience is experienced if the amount of ventilation originally intended, *viz.*, 50 cubic meters = 1750 cubic feet per person, per hour, be employed. But in the First Chamber the amount must not exceed 35 cubic meters =1225 cubic feet, otherwise complaints are heard about drafts and cold about the legs. It can, of course, happen that some one very sensitive person in either Chambers makes complaints, but then a way out of the difficulty is found by wholly or partially closing the ventilating valve beneath the complainer's chair. But with downward ventilation, complaints were general, *i. e.*, they were heard from many persons. It is, of course, impossible to satisfy *everybody* as personal opinions are so various, but it can be safely said, that with upward ventilation and the above-named

ventilation-amount in the two rooms, the ventilation gives general satisfaction. Should any complaints be heard, it is generally from the First Chamber at the close of a sitting lasting many hours; complaints are more seldom heard from the Second Chamber. The *duration* of a current of air has, of course, some influence too, in that, though it is not felt as an inconvenience when lasting but half an hour, it can become very noticeable at the end of an hour and rather troublesome during the ensuing hour.

And besides, it is not at all sure that the drafts felt come from the gratings beneath the seats. Great care must be taken with the ventilation of the galleries. If these be poorly occupied, the ventilation should be greatly restricted, for otherwise, in consequence of its lower temperature, the incoming mass of air will fall over the railings down upon the bald heads (mostly existing in the First Chamber). Should the galleries be well filled there is no danger of this, for then the air is warmed by the public, and rises towards the ceiling.

The conditions of the temperature during the winter session, January-May, have been very favorable. In the First Chamber the rise in temperature after a sitting of several hours' duration and with well-filled galleries, has, as a rule, been 1.50 degrees Cent. (2.7 degrees Fahr.). The fresh air has, during this period, been introduced at a temperature 2.0 degrees Cent. (3.6 degrees Fahr.) *higher* than that of the room. The result given may cause astonishment, but can be explained by the fact that the air introduced is *dry* (humidifying apparatus exists but is not used), and that the room is large in proportion to the number of the Members. It is also common in our First Chamber that a great number of the Members do not put in an appearance during a sitting. This fact, again, necessitates a smaller quantity of air per place, and a higher degree of temperature for the in-streaming air in order to avoid drafts. The temperature in the galleries does not, as a rule, become higher than that of the floor of the House, even when the galleries are well filled. This is explained by their lesser distance from the large glass roof or ceiling, the warming of which from above is not carried up to the temperature of the room, and thus, in some degree, has a cooling effect.

As already mentioned, the amount of ventilation in the Second Chamber has been greater than that in the First and the air has there been introduced at a temperature 2 degrees to 3 degrees

Cent. (3.6 degrees to 5.4 degrees Fahr.) *below* the temperature of the room. And when this has been done it has been possible to keep the temperature of the room constant, even when the galleries were filled. The Members of the Second Chamber have thus shown themselves less sensitive, to a noteworthy degree, than the gentlemen of the First Chamber.

During the summer session we had only one day of, what was for us, unusual warmth, *viz.*, 27 degrees Cent. (80 degrees Fahr.). On this day the temperature in the fully filled galleries of both Chambers rose to 22.5 degrees Cent. (72.5 degrees Fahr.). Otherwise, the temperature kept within normal bounds. There is no air-cooling apparatus in use, but the capacious air-ducts (as large as ordinary corridors) and the many introductory chambers the air has to pass before it enters the Debating-Rooms, serve sufficiently well for cooling-surfaces.

The result of the comparison between the two systems is pretty remarkable. The writer of this article—the constructor of the heating and ventilation systems of the Riksdag's House—was positively convinced of the superior merits of the system of upward ventilation. But the German professor who, at the time, was called in to give his opinion on the matter, recommended the downward system. Fortunately we were able to insist on having both systems adopted and tried. But the downward system now constitutes, for the time being, at least, a closed chapter.

It may be mentioned finally, that the same results have been experienced at the German Reichstag's House in Berlin as those learned at Stockholm, and that the downward system has been replaced by the upward one.

DISCUSSION.

President Kent: I will call attention to the fact that the objections to the downward system mentioned in the paper are in consequence of drafts and not in consequence of pollution of the air. I think it is well for the time being, at least, to confine our discussion to that question. Mr. Bolton, will you open the discussion?

Mr. Bolton: I cannot agree with the attempt made to show that the conclusion reached is conclusive. We are not given any data as to the amount of air. That would be an important feature.

Another thing is extraction of the air and introduction at the very feet of the occupants of the room. The general practice in this city, I think, is not to do that. I notice that some of the members complained of cold feet. When the air is introduced at the end of the seat, below the temperature of the room, the tendency is to go against the legs of the audience.

President Kent: The paper says the downward system is a closed chapter.

Mr. Barron: The German and Swedish gentlemen seem to have that same old quarrel going on. They want to decide positively whether downward extraction or upward extraction is right. The question will never be answered because both are right—or both can be made right. It is a question of which is desired. Occasionally heating engineers debate the question, but you can never reach a conclusion because you can point to buildings in this city where downward extraction is satisfactory and also to buildings where upward extraction is satisfactory. The author of this paper is one of the strong-minded ones who believes upward ventilation is proper. A man of ordinary ingenuity can always demonstrate he is right. The superintendent of the machine shop is always right, no matter how good the machinist may be who makes the suggestion. It is an interesting paper.

Mr. J. A. Donnelly: On p. 3 it says: "The valves in four cylindrical air-shafts proceeding from the hot-air chamber are so adjusted that the air enters the air-distributing chamber at the temperature and to the amount desired"; while on p. 5 it says: "Its steam valve is controlled from the regulating room, but there are in addition two large mixing-valves for cold and warm air, which valves are also controlled from the regulating room." From the way the paper reads, not assuming anything, it seems to me that mixing dampers are used for mixing cold and warm air on downward ventilation. It is doubtful if mixing dampers are used in upward ventilation. It looks to me as if it was hardly a fair test to make—the number is not given, but one hundred or perhaps more openings are in the floor to admit the air, and then the current is reversed, all the air put in the top at one opening.

The outlets underneath the seats are better calculated to mix the air coming out so as to get uniform distribution. I do not think if we were trying downward ventilation in any building I

have seen recently constructed we would try to put hot air in with mixing dampers in any such manner as shown here. We would give the air what we would consider a little bit of a chance. I do not think the conditions are similar for upward and downward ventilation.

Mr. Barron: Mr. Wolfe has had a great deal of experience, and I would like to hear from him.

Mr. Wolfe: I am hardly prepared to discuss this. I have had some experience, and am very much in favor of downward ventilation. The paper fails to state that any tests were made of the purity of the air. By downward ventilation you introduce the warmed air, which in entering naturally spreads across the ceiling and seeks the cold surface of the outer walls. I remember once we agreed to heat a building—not the whole city—there was complaint, and we contended our installation was right. The next week there came a storm that blew in all the windows upon one side of the building, frames and all. That is the trouble with nine-tenths of the buildings where they complain of cold floors, etc. It don't come from the registers, but from the window drafts and leakages of that kind, the cold air being heavier goes to the floor, and they complain of cold feet. In small buildings, for good circulation—I mean the ordinary room, 28 x 30 x 12—you will get better results—I mean the air will be more evenly distributed—and a more even temperature maintained by downward rather than by upward ventilation. That has been my experience.

About upward ventilation, when in practice in Massachusetts I examined a building said to be the best ventilated in the State. They introduced at the floor line, at the register, about 45 cu. ft. per capita per minute and exhausted through a register in the ceiling directly over the intake. The air in the room was as bad as air could be. It simply passed up, and there was no reason why it should circulate. I think we all must consider the laws of gravity as a great factor in our calculations.

Mr. Barron: If there is anybody here who knows anything about the Judson Memorial Hall I think he should tell us about it. My impression is that the trouble is due to mismanagement. I remember that Henry Adams, in this building, told me about a design of his I had seen in the papers, and admired, for a post-office or custom house not far from New York City, and we were

talking it over and he says: " I have had a little experience during the last week. I went there and found the ducts in one of the jobs supplying no air, the ducts being in small rooms outside the building and bricked in. I found this whole space was occupied as a storage room to store paper and other material. Of course they couldn't get the air through that material." That is what occurs in nine cases out of ten—complaints are largely due to improper management.

Mr. Dahlgren (contributed since the meeting): It is my wish to say a few words with regard to the discussion of my paper on the ventilation of the new Riksdag House, Stockholm, which took place at the meeting of the American Society of Heating and Ventilating Engineers on the 17th of January, 1906.

Judging from a short report in *The Heating and Ventilating Magazine* (No. 2, 1906) my very brief paper has been misunderstood in some points.

In answer to Mr. Bolton, I wish to state that the amount of air was given, viz., as being 1,225 cubic feet per hour in the Debating Room of the First Chamber, and 1,750 cubic feet per hour in the corresponding room of the Second Chamber.

In answer to Mr. Barron, it is my wish actually to assert that the conditions in all these rooms with fixed seats are so similar that, by means of proper tests, one should be able to verify in a general way that the one method is superior to the other. Of course, this course does not prevent a very well arranged downward system of ventilation from being more advantageous than a somewhat badly executed system of upward ventilation.

In answer to Mr. J. A. Donnelly, I wish to remark that when I have stated that full justice was done to both systems it ought to be consequently understood that mixing dampers were employed too, both in the upward and in the downward ventilation systems. This was the case, although it was not altogether distinctly stated in my paper. But, on the other hand, mixing dampers are, very naturally, not employed in the short air flues which lead up through the floor under the chairs. When the air enters these flues from the air-distributing chamber it has already acquired a well-regulated and perfectly equable temperature. The problem to be solved was to get the air to stream out in equal quantities through, for example, 100 openings, and this without the velocity of the out-streaming air exceeding 10 inches per

second, when the ventilation is strongest. In order to attain this object, it is necessary to bring about in the air-distributing chamber a certain air-pressure which is greater than the pressure in the Debating Room. This pressure produced a pretty high velocity of the air (about 8½ feet per second) on its passing the bottom dampers in the air flues. This velocity must be killed in the short flue so that the air can enter at a minimal velocity through the gratings mentioned. This is done by means of the described form of construction of the gratings in combination with the shape of the flue itself and its damper.

In reply to Mr. Wolfe's criticism that no tests had been made respecting the purity of the air in the one case and in the other, I beg to remark that this matter is not, just here, one of the chief questions, for there is no doubt but that the degree of purity can be satisfactory in both cases. It is true that there is good reason to assume, and it is said that elsewhere it has been proved by investigation, that upward ventilation carries off the products of expirations and transpiration more rapidly than does downward ventilation. But it was not my intention to touch upon that question. The chief question was that of draught—which system is most free from draughts; which system can act in such a way that its existence is not made evident. That system is the best.

CLV.

POWER REQUIRED TO THREAD, TWIST AND SPLIT WROUGHT IRON AND MILD STEEL PIPE.

BY T. N. THOMSON.

(Member of the Society.)

The matter of threading pipes, although apparently a small detail in heating installations, is nevertheless a very important factor in the heating trade. It is the threads that hold the several parts of a heating system together, and it is the degree of perfection obtained in the cutting of the threads that influences to a considerable extent the tightness of the innumerable joints in a heating system.

Few things are more tantalizing to the fitter than a number of leaky joints or splits developing in a system of piping that has been thoughtfully planned and has been erected with considerable care and a great deal of labor. So I feel that anything which can be done to obtain more perfect joints and fewer splits and that will reduce the amount of power required to make the joints is a matter worthy of consideration by this body.

Some time ago my attention was called, by the National Tube Company, to steps that are being taken by them along the line of inducing manufacturers of dies to make certain improvements in the form of the dies that will enable the fitters to cut better threads with a smaller expenditure of energy than obtains at present with the ordinary forms of dies. Of course it is human nature to suppose that the object of the pipe manufacturers in placing before the trade, free of charge, the results of their investigations, researches and experiments along this line, is to further the interests of the pipe-making business, and no doubt it is. But this is no reason why so important a matter should not receive the careful consideration of the American Society of Heat-

ing and Ventilating Engineers, and most particularly those of you who are in the contracting business.

I have investigated the matter a little from an educational standpoint on behalf of the International Correspondence Schools of Scranton, with a view to imparting reliable instruction to our students, many of whom are located in out-of-the-way places, and even in foreign lands. Before commencing to investigate this matter, I at once realized that in doing so I placed myself between the Devil and the Deep Sea, so to speak. On one side of me are the pipe manufacturers and on the other side the consumers. The manufacturers discovered long ago that in order to supply the increasing demand for pipe in this country it was considered necessary to make use of the quite recent methods of producing weldable mild steel. By this process the pipes are made by the mile, so to speak, and are thus comparatively cheap and within the reach of all, rich and poor alike. No doubt this is one of the reasons why the steam fitting trade has reached such gigantic proportions in the building trades. Probably from 60 to 80 per cent. of the pipe used in the United States to-day is steel pipe. Hence the necessity of the trade having tools designed to properly work this metal.

There are two kinds of steel pipe and two kinds of wrought iron pipe on the market, namely, good wrought iron and poor wrought iron, good steel and poor steel, and you cannot ordinarily distinguish between them till after the goods are bought and the men are cutting and threading them on the job. Some will split, some will chip as if made of crystal, in some the threads will strip, while others may even break across like glass bars. What can you do with pipe like that? Do not pay for it; ship it back at once and quit dealing with that concern. Perhaps you got a special price on that pipe? Well, quit special prices on carloads of questionable pipe. The margin of profit in heating contracts is too close to warrant any contractor in playing with cheap steel or iron pipe of unknown make. Old scrap iron and steel are good enough for use in the manufacture of other articles of commerce, but not in the manufacture of pipe. Many people who have had galling experiences with poor pipe may, without further thought, form a deadly relation between the improved form of die and the poor pipe. And it is true that the die will enable the fitter to thread pipes that would give him all manner of trouble with the ordinary

form of dies, but at the same time it is a solid fact that progress in the manufacture of dies must not cease because there is poor pipe on the market and because the die question has been brought up by the pipe makers. The great fundamental fact is that the trade must have very good uniform dies, and very good uniform pipe. If they cannot both be obtained at once, then let us get one at a time. It does not matter a great deal which one comes first as long as the desired results are ultimately obtained. The die question is the smaller one of the two, and probably is the one that would naturally come up first, anyhow. After the pipe-working tools are made perfect and the mechanics are trained to keep them in good condition, then the trade can, with a clear conscience, demand from the manufacturers a grade of uniformly good pipe that will withstand all the strains and stresses incident to the unavoidable rough usage, threading, bending, and fitting up operations. Then, and not till then, will this gnawing trouble of split pipe come to an end.

It was evident that a knowledge of the physical properties and general characteristics of both wrought iron and mild steel pipe was essential as a forerunner of an investigation into the dies. Therefore I made a tour of some of the largest pipe mills in America. I carefully followed the process of making the wrought iron pipe from the puddling furnaces, and the steel pipe from the blast furnaces, all through the mills, to the shipping department. The rolling, welding, straightening, threading, testing, and shipping processes are exactly the same for wrought iron as for steel pipe, the only difference being in the composition and properties of the two metals. To all external appearance they are the same. I had a number of ring tests made to show the peculiarities of the two metals and the relative strength of wrought iron and steel pipe. It was a noticeable fact that the wrought iron rings broke very easily under the straightening out process by which a combination of tensile and cross strains are developed. Fig. 1 shows at (*a*) how the test was applied. A ring of pipe about 1 inch to 1½ inches wide is secured by two hooks in a testing machine. The machine is set in operation and the hooks are pulled apart until the ring breaks, the pull applied to the ring by the machine being indicated by an electric measuring device. The rings tested were cut from lap welded pipe, the welds in the tests were placed as at (*a*), Fig. 1, so as to test out the weld with relation to the strength

of the other parts of the pipe. The illustration shows at (*b*) how the mild steel rings generally broke, and at (*c*) how the wrought iron rings frequently broke. The tests developed the fact that some of the welds were stronger than the pipe, while others were weaker than the pipe. The strength of the weld depends a great

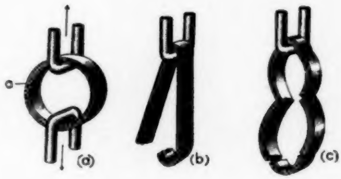


Fig. 1.

deal upon the amount of the lap; those that did break at the weld were apparently short laps.

Table No. 1 shows the result of some tests I had made on 8 rings of 6-inch pipe—four being wrought iron and four being mild steel. I made these principally to observe the ductility of the metals in pipe form and the fractures, but the results are nevertheless interesting:

TABLE 1.

Ring Test—Lap Weld Pipe.

Wrought Iron. Actual Breaking Strength.	Mild Steel. Actual Breaking Strength.
4,100 lbs.	5,300 lbs. Defective weld.
3,100 "	35,000 "
3,000 "	29,000 "
2,400 "	18,000 " Hooks slipped.

Table No. 2 was made by the National Tube Company and is more extensive than the above. It shows the tensile strength of the metal, the tensile strength of the seam and the relative strength of the seams as compared with their respective pipes.

TABLE 2.

WELD TESTS.

Butt Weld Iron and Steel Pipe.

	METAL. Tensile Strength lbs. per sq. in. Transverse Section.	WELD. Tensile Strength lbs. per sq. in. Transverse Section.	Per cent. of Tensile Strength of Metal.
Iron	36,910	31,100	84.26
	35,280	28,650	67.04
	30,530	23,440	76.84
	32,870	16,130	49.07
	35,720	27,630	77.36
	34,400	25,620	74.48
	31,360	21,550	68.72
	37,700	26,440	70.14
	35,950	25,350	70.52
Average	34,520	24,540	70.93
Steel	62,000	46,420	74.86
	62,440	48,870	78.26
	60,860	44,890	73.76
	60,180	52,900	87.90
	62,180	41,380	66.54
	60,000	35,050	58.42
	67,000	62,280	92.96
	61,320	52,480	85.58
	60,660	30,510	50.30
Average	61,850	46,080	72.28

Perhaps the most important feature in this table, as far as we are concerned at the present moment, is the fact that the ratio of strength between seam and pipe varies considerably. The strongest iron seam is 84.26 per cent. the strength of the pipe; the weakest iron seam is 49.07 per cent. the strength of the pipe. The strongest steel seam is 92.96 per cent. the strength of the pipe, and the weakest steel seam is 50.30 per cent. the strength of the pipe. No doubt these were samples of good pipe. This table, therefore, serves to emphasize the fact that neither wrought iron pipe nor steel pipe is uniform throughout in character and strength. It particularly shows how some pipes will split more easily than others while being worked.

The plumbing and heating trades experience a great deal of trouble with pipe; the seams frequently become split while the pipes are being threaded, and considerable loss of time and money is occasioned all around. The reason why the seams become split is because they are not as strong as the rest of the pipe. If they were as strong as the pipe, then it would appear that the pipe would either twist or tear when an excessive force tends to open the seams.

Most of the splits in the trade are produced, I believe, in threading butt welded pipes. The lap welded pipes evidently do not split so frequently. The teeth of the dies in cutting the thread at the butt weld seem to catch squarely against the weld as shown in Fig. 2, which exaggerates the thickness of the pipe, but clearly shows by arrows the direction of the principal forces that tend to split the pipe at the seam. The cutting face *a* of the die is radial,

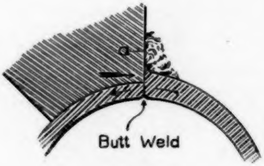


FIG. 2.

that is, it points toward the center of the pipe. The cutting edge, therefore, is a right angle. This kind of die, I understand, is today used more or less by nearly every firm in the heating business. I call this an imperfect design, because it does not have an acute angle cutting edge like any other cutting tool. All tool manufacturers know that there is a certain angle or rake that is best adapted for cutting different metals in the most easy and most perfect manner, but it seems that the die makers are very slow in

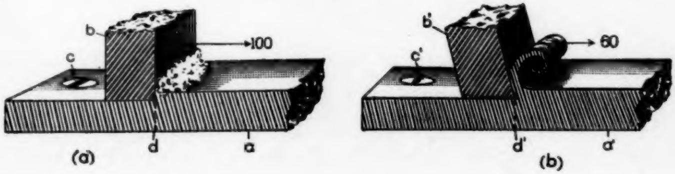


FIG. 3.

methodically introducing this principle into the die business. Fig. 3 shows at (*a*) the tearing out process of metal cutting by the imperfect dies in common use, and at (*b*) the correct principle of cutting metal as it is recognized by expert metal workers. Suppose a a^1 to be plates of mild steel such as is commonly used in pipe manufacture, then according to tests that have been made, the power required to pull the cutter b is about 60 per cent more than that required to pull the cutter b^1; and if a relief is made on

cutter b^1, the difference will be more nearly 100 per cent. If the plates were made of wrought iron, the power required to pull b would be approximately 45 per cent. more than would be required to pull b^1. The ratio of the powers, of course, will vary with the composition and physical properties of the metals, but for ordinary wrought iron and mild steel, as they are found in pipe form, the aforesaid ratios, I believe, are approximately correct.

Suppose that the plates a *and* a^1 were bolted down tight at c c^1, and suppose that they had been made in two pieces with butt welded seams as shown by dotted lines at d d^1, it will be easily seen that the tensile stress on the seam d is about 100 units, while the tensile stress on the seam d^1 is only about 60 units, the thickness

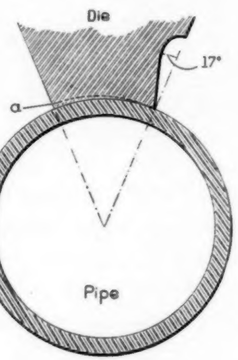


FIG. 4.

of the plate and the depth of the cut being the same in both cases. It is, therefore, evident that the seam d will be more readily split than seam d^1, assuming that they are both welded with the same degree of perfection. And so it is with the butt welded seams of both wrought iron and mild steel pipes, the square cutting edge of the old-fashioned die will split the seams of pipe that can be easily threaded with dies of the correct form.

A large number of experiments on different forms of dies, the cutting rake, etc., go to show that the best angle of rake for dies that are to be used only on wrought iron pipes is about 12 degrees; the best angle of rake for dies to thread only mild steel pipes is about 20 degrees, and the best angle for a die that is suitable for both wrought iron and mild steel pipes is about 17 degrees, as shown in Fig. 4, and it can be greatly improved by having the die

cut with a relief, as shown by dotted line *a*, so that the die will bear on the pipe only at the cutting edge.

Fig. 5 shows how the power was measured for threading both

FIG. 5.

wrought iron and mild steel pipe with both the square edge die and the improved die. A test made on this machine with two samples of good pipe gave the results shown in Table 3. The dies were both in good condition; it is from this trial that the preceding ratios are determined.

TABLE 3.

KIND OF PIPE.	OLD FORM OF DIE. Pull in Pounds on a 21-inch Lever.	NEW FORM OF DIE. Pull in Pounds on a 21-inch Lever.
1¼-inch wrought iron.	83 to 87 lbs. pull.	58 to 62 lbs.
1¼-inch mild steel.	100 to 111 lbs. pull.	60 to 65 lbs.

The samples used in the above test were ordinary good quality pipe picked out at random. A series of tests along this line would no doubt develop somewhat different results according to the kind and hardness of the material, but I believe the above is a fair average for good pipe.

It shows that the power required to thread mild steel pipe with the new die is not much more than that required to thread wrought iron pipe with the same die and much less than the power required to thread wrought iron pipe with the common die.

This is an improvement in dies that makes the threading operation very easy on the men. If men are to be expected to do good work and keep it up, all needless expenditure of energy should be eliminated. I do not see the use of a fitter pulling 100 pounds on a stock arm if a pull of 60 pounds can be made to accomplish the same purpose. It seems a pity that a suggestion for the improvement of dies should come from the pipe mills, but it appears that they have made the greatest investigations and experiments and have given the matter more study and thought than any other party, and they consequently are entitled to the floor. An objection may be raised to the effect that if a pipe is so poor that it will split while being threaded, it has no right to be installed as part of a heating or power system. This objection is strictly correct, but it is no reason why we should depend on testing pipe for splitting proclivities by cutting threads on them. The fact of the matter is that all the pipes should be tested at the mills, and all imperfect pipes should be cut up and sent to the scrap pile. A number of the large mills test all the pipe that is shipped, every pipe threading machine being equipped with a corresponding measuring and testing machine and a trained crew, but I do not know whether all pipe mills are thus equipped.

To depend on the threading process for testing pipe seams is, in my estimation, absolute foolishness, for a large amount of pipe is fitted up in every job that never is subjected to the twisting strain produced by threading. For example, a number of full lengths constitute part of the mains, they are threaded in machines at the pipe mills by properly made dies. The risers are constituted principally of pipes that have a short piece cut off one end, and the end threaded. The only piece that has been subject to twist is the short part that came between the vise and the die. The remainder of the length has had no twist except a little at the other end that may be applied by the " Stillson " in screwing up the pipe.

Of course it is advisable to take all precautions to prevent poor pipe from getting into a heating or power system, but it seems to me that better results will be obtained by an intelligent inspection of the seams and by a series of torsion tests that will actually test the strength of the welds the full length of the pipes. Of course the right place to have pipes tested is the place where they are made. It, therefore, seems to me that torsion tests should be applied at the mills. Probably the present hydraulic testing machines can

be slightly changed so that each pipe while being tested with water pressure will in the same operation be subjected to a certain amount of twist that will immediately prove whether the pipe is water tight and whether it will split in being handled by the trade.

To secure some definite information regarding the power required to split or twist pipe, a number of torsion tests were very kindly made, at my suggestion, by the National Tube Company. The sizes twisted were ½-inch, ¾-inch, and 1 inch. The pipes were selected at random. I purchased a lot of common merchant pipe on the open market by cutting a piece out of a length in different bundles. No two pieces were taken from the same length nor

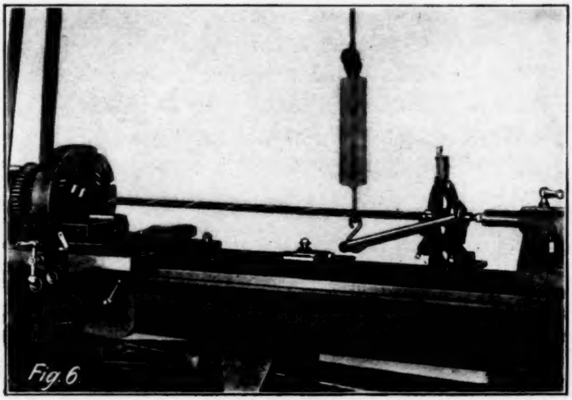


Fig. 6.

from the same bundle. In this way I believe we obtained a fair average. Each sample to be twisted was 6 feet long. Fig. 6 shows the machine used to make the test. One end of the pipe was secured to the chuck of a lathe, the other was secured to a clamp having a 3-foot lever, which was held up by a spring balance as shown. The machine was put in motion, and the power required to twist the pipes or split them was recorded on the spring balance and noted. Each piece of pipe was subject to precisely the same conditions. The results of the tests were tabulated in detail and are altogether too voluminous to be incorporated in this paper. The following, however, are a few of them and will be sufficient to show how steel and wrought iron pipes behave under excessive torsional stresses:

TABLE 4.

(N. T. Co.)

TWISTING TESTS ON BUTT-WELDED PIPE.—SUMMARY.

Size.	Material.	Wt. per ft. Lbs.	Variation from card wt. Per Cent.	Maximum pull on 3-foot lever lbs.			No. of Turns in 6 feet.	Per Cent. fail d in weld.
				Low.	High.	Average.		
½ inch	Steel	.816	−2.2	90	120	100	15	0
"	Iron	.803	−4.2	40	98	68½	4¼	73
"	Iron	.792	−5.2	20	113	81	5¼	66
"	Iron	.842	+0.6	50	85	65	2¼	100
¾ inch	Steel	1.082	−2.9	160	185	172	8	13
"	Iron	1.097	−1.6	140	160	154	6.2	33
"	Iron	1.127	+1.0	80	176	136	3¼	66
"	Iron	1.104	−1.0	50	160	107	2¼	90
1 inch	Steel	1.658	−0.7	180	340	300	5½	13
"	Iron	1.503	−4.4	220	292	256	4¼	46
"	Iron	1.616	−3.1	170	300	250	3½	33
"	Iron	1.620	−2.8	100	320	258	2¾	66

Table No. 4 is simply a summary of a large number of detail tables. In making up the latter tables, the record of every piece of pipe is noted separately. The following tables apply only to

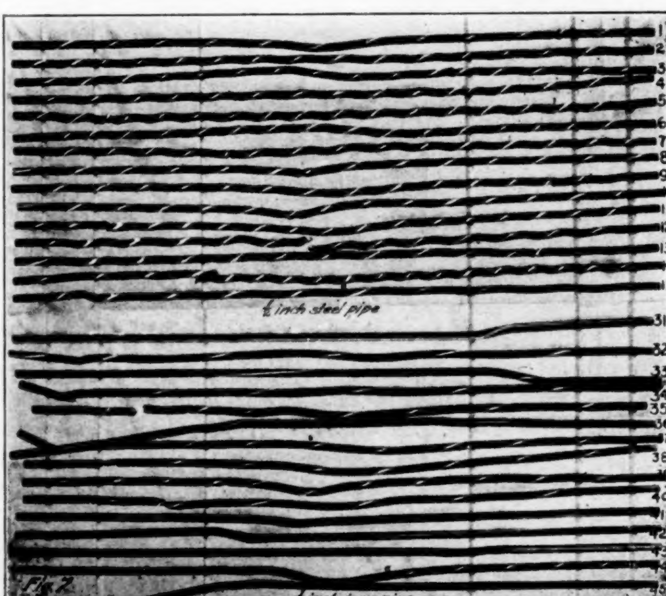


FIG. 7.

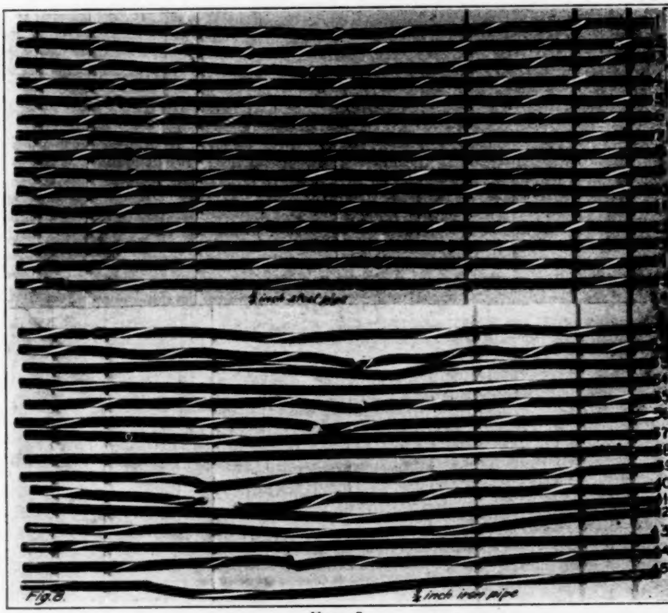

inch steel pipe
7
8
9
10
11
12
13
14
15
Fig. 8
inch iron pipe

FIG. 8.


1 inch steel pipe

FIG. 9.

the pipes shown in Figs. 7, 8 and 9. As the photos of the twisted pipes are too numerous to be all presented in this paper, I have selected the steel samples and the middle iron samples of each size. It would not be fair to put up the last line of samples of iron pipe against the steel photos, because this iron pipe was very poorly welded, as can be seen by Table 4, and a false impression of wrought iron pipe may be formed. The middle sample is the product of a well-known maker and is known to be good wrought iron pipe. Therefore, Figs. 7, 8 and 9 show results of twisting tests on good steel pipe and good wrought iron pipe, and the data for these tests are given in detail in Tables 5, 6 and 7.

TABLE 5.

(N. T. Co.)

FOR PIPES SHOWN IN FIG. 7.

½-Inch Steel.

Number of Pcs.	Weight pr. pce. Lbs.	Length. Ft.	Weight pr. ft.	Variation from card. Wt. p.c.	Max. Pull on 3 ft. Lever lbs.	Turns.	Remarks.
1........	4.81	6.00	.801	− 4.3	105	12¾	Did not break.
2........	4.81	6.00	.801	− 4.3	110	15	" " "
3........	5.00	6.00	.833	− .5	115	16	" " "
4........	4.75	6.00	.791	− 5.5	105	15¼	Broke off.
5........	5.06	6.00	.843	+ .7	110	15½	Did not break.
6........	4.88	6.00	.813	− 2.9	115	16¼	" " "
7........	4.75	6.00	.791	− 5.5	110	14¾	" " "
8........	4.88	6.00	.813	− 2.9	110	13½	" " "
9........	5.00	6.00	.833	− .5	110	15	Broke off.
10........	4.75	6.00	.791	− 5.5	100	14¾	Did not break.
11........	4.88	6.00	.813	− 2.9	115	18½	Broke off.
12........	5.06	6.00	.843	+ .7	90	14	" "
13........	4.81	6.00	.801	− 4.3	110	13¾	Did not break.
14........	5.00	6.00	.833	− .5	120	20¼	Broke off.
15........	5.06	6.00	.843	+ .7	105	9	" "
Average..	....	....	.816	....	109	15	

½-Inch Iron.

Number of Pcs.	Weight pr. pce. Lbs.	Length. Ft.	Weight pr. ft.	Variation from card. Wt. p.c.	Max. Pull on 3 ft. Lever lbs.	Turns.	Remarks.
31........	4.75	6.00	.791	− 5.5	33	½	Failed in weld.
32........	4.88	6.01	.810	− 3.2	90	9⅛	Twisted off.
33........	4.69	6.00	.781	− 6.6	67	2	Failed in weld.
34........	4.81	6.00	.801	− 4.3	113	6	" " "
35........	5.12	6.01	.852	+ 1.8	105	10	" " "
36........	4.81	6.01	.800	− 4.4	73	3	" " "
37........	4.50	6.02	.747	− 10.8	113	9	Broke off.
38........	5.00	6.00	.833	− .5	100	9½	" "
39........	4.63	6.00	.771	− 7.9	90	11	" "
40........	4.88	6.00	.813	− 2.9	95	7½	" "
41........	4.63	6.00	.771	− 7.9	73	2	Failed in weld.
42........	4.69	6.01	.780	− 6.7	55	1¼	" "
43........	4.69	6.00	.781	− 6.6	20	¾	" "
44........	4.75	6.01	.790	− 5.6	100	13	" "
45........	4.63	6.01	.770	− 8.0	87	2	" "
Average..	....	....	.792	− 5.2	81	5¼	

TABLE 6.

(N. T. Co.)

FOR PIPES SHOWN IN FIG. 8.

¾-*Inch Steel.*

Number of pcs.	Weight pr. pce. Lbs.	Length. Ft.	Weight pr. ft.	Variation from card. Wt. p. c.	Max. Pull on 3 ft. Lever lbs.	Turns.	Remarks.
1	6.38	6.00	1.063	− 4.6	170	7¾	Did not break.
2	6.50	6.00	1.083	− 2.7	178	8¼	" " "
3	6.56	6.00	1.093	− 1.9	170	8½	" " "
4	6.50	6.00	1.083	− 2.7	178	8¼	" " "
5	6.56	6.00	1.093	− 1.9	170	7	" " "
6	6.50	6.00	1.083	− 2.7	180	9¾	" " "
7	6.44	6.00	1.073	− 3.8	160	5	Broke off under clamp at [end.
8	6.38	6.00	1.063	− 4.6	165	7½	Did not break.
9	6.31	6.00	1.052	− 5.6	165	6½	" " "
10	6.50	6.00	1.063	− 4.6	175	7½	" " "
11	6.75	6.00	1.125	+ 0.9	180	8½	" " "
12	6.68	6.00	1.113	......	185	9¼	" " "
13	6.38	6.00	1.063	− 4.6	170	7¼	" " "
14	6.50	6.00	1.083	− 2.7	180	9½	" " "
15	6.56	6.00	1.093	− 1.9	160	4½	Failed in weld.
Average	....	....	1.082	− 2.9	172	8	

¾-*Inch Iron.*

31	6.75	6.01	1.124	+ 0.8	150	2	Failed in weld.
32	6.88	6.01	1.145	+ 1.8	176	7	Broke off.
33	7.00	6.00	1.167	+ 4.7	140	3	Failed in weld.
34	7.12	6.00	1.187	+ 6.5	120	2	Broke off.
35	7.00	6.01	1.165	+ 4.5	160	7	Did not break.
36	7.00	6.00	1.167	+ 4.7	140	4½	Failed in weld.
37	6.12	6.00	1.020	− 8.5	100	1	" " "
38	6.56	6.00	1.093	− 2.0	80	1½	" " "
39	6.88	6.01	1.145	+ 2.7	140	4¾	" " "
40	6.68	6.00	1.113	......	120	1	" " "
41	6.44	6.00	1.073	− 3.8	100	1	" " "
42	6.88	6.00	1.147	+ 2.9	140	3½	" " "
43	6.50	5.99	1.084	− 3.8	170	6	Broke off.
44	6.94	6.00	1.157	+ 2.8	165	7	Did not break.
45	6.68	6.00	1.113	......	140	2½	Failed in weld.
Average	....	....	1.127	+ 1.0	136	3½	

TABLE 7.

(N. T. Co.)

FOR PIPES SHOWN IN FIG. 9.

1-*Inch Steel.*

Number of pcs.	Weight per pce. Lbs.	Length Ft.	Weight pr. ft. pounds.	Variation from card. Wt. p. c.	Max. pull on 3 ft. Lever lbs.	Turns.	Remarks.
1	10.0	6.00	1.667	......	340	6	Did not break.
2	10.12	6.00	1.687	+ 1.1	300	6¼	" " "
3	9.94	6.00	1.657	− 0.7	320	7¼	" " "
4	10.00	6.00	1.667	......	280	5	" " "
5	9.81	6.00	1.635	− 2.0	310	5¼	" " "
6	10.12	6.00	1.687	+ 1.1	340	6½	Broke off.
7	9.94	6.00	1.657	− 0.7	320	6¾	Did not break.
8	9.88	6.00	1.647	− 1.3	330	5	" " "
9	9.94	6.00	1.657	− 0.7	320	6	" " "
10	9.88	6.00	1.647	− 1.3	220	2½	Failed in weld.
11	9.94	6.00	1.657	− 0.7	320	6	Did not break.
12	10.12	6.00	1.687	+ 1.1	330	6	" " "
13	9.94	6.00	1.657	− 0.7	300	6	" " "
14	9.81	6.00	1.635	− 2.0	180	1	Failed in weld.
15	9.81	6.00	1.635	− 2.0	300	5	Did not break.
Average..	....	....	1.658	− 0.7	300	5½	

1-*Inch Iron.*

Number of pcs.	Weight per pce. Lbs.	Length Ft.	Weight pr. ft. pounds.	Variation from card. Wt. p. c.	Max. pull on 3 ft. Lever lbs.	Turns.	Remarks.
31	9.25	6.00	1.540	− 7.7	240	3¼	Nearly twisted off.
32	9.50	6.02	1.580	− 5.2	260	4	" " "
33	10.00	6.00	1.667	......	280	4	" " "
34	10.12	6.02	1.680	+ 0.7	300	4	Twisted off.
35	9.44	6.00	1.573	− 5.7	240	2½	Failed in weld.
36	9.63	6.02	1.600	− 4.1	270	4¼	Nearly twisted off.
37	9.75	6.02	1.620	− 2.9	220	1¼	Failed in weld.
38	10.06	6.02	1.671	......	170	1	" " "
39	10.38	6.04	1.718	+ 2.6	220	1½	" " "
40	9.25	6.03	1.531	− 8.2	240	4	Commenced to twist off.
41	10.12	6.04	1.678	+ 0.6	280	4	Failed in weld.
42	9.44	6.02	1.566	− 6.1	256	3	Commenced to twist off.
43	9.68	6.00	1.613	− 3.3	260	3¼	" " " "
44	9.56	6.01	1.590	− 4.7	260	4	" " " "
45	9.75	6.01	1.620	− 2.9	260	4	Twisted off.
Average.	....	....	1.616	− 3.1	250	3⅓	

The tests of the National Tube Company I am satisfied are very thorough and are exceedingly valuable records, but as they were all made on machines, and as ½ inch, ¾ inch and 1-inch pipes are threaded by hand in pipe vises, I made a number of tests at the laboratory of the International Correspondence Schools with a view of obtaining as nearly as possible the strains that are actually placed on pipes in practice. We secured a number of samples from different supply houses and from the pipe racks in the plumbers' and fitters' shops in Scranton, the idea being to test the regular nondescript merchant pipe in common use and find how much power is actually required to thread and split this class of pipe by

the mechanics on the jobs. To make the threads, we borrowed the tools from the trade, so that there also we would get actual practical results. In making the tests we used a pipe vise and stillson wrenches so that the action of their teeth and the shifting of grips would all form a part of the tests. Of course it must be expected that tests made in this way will develop entirely different results from tests made in machines with properly designed clamps and a steady application of the power. While the International Correspondence Schools tests give an idea of what takes place at the pipe vise with hand tools, the National Tube Company tests show what may be expected at the threading machine.

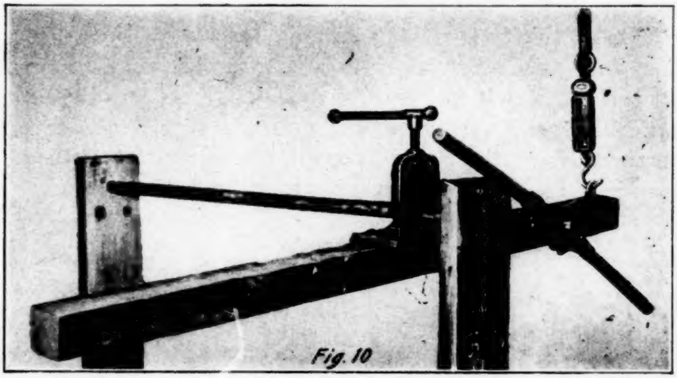


FIG. 10.

Fig. 10 shows how we rigged up the apparatus. Two rigid 2 by 8-inch uprights each have three holes bored through as shown, one being for 1-inch pipe, one for $\frac{3}{4}$-inch pipe and the other for $\frac{1}{2}$-inch pipe. The pipe in all cases was grasped by a vise which was bolted to the center of a 4-inch by 4-inch timber. The pipe was lubricated where it passed through the uprights. As the arms of the stocks were 18 inches long from the center of the die to the extreme end, and as the actual distance of the center of a man's hand will be about 2 inches from the end of the stock arm, we attached an eye bolt to the 4-inch by 4-inch timber, so that the hook of the spring balance would be 16 inches from the center of the pipe in the vise. In this way we can read on the spring balance the amount of pull a fitter has to apply to the dies. For

convenience, the power required to twist and split is also given with the balance at a 16-inch lever.

The difference between the threading operation which is shown in Fig. 10 and the twisting operation is that in the latter the dies were removed, stillson wrenches were applied to the other end of the pipe where it passes through the upright and the pipe was twisted by these wrenches. Of course the wrenches chewed into the pipe and so did the vise, but this is a true condition of the trade and it is well for us to know what happens under such conditions.

In reading the spring balance, we noticed great variations and it was rather difficult at times to obtain a definite reading. The records were all taken during steady pulling. When the dies were pulled quickly in jerks, or run dry, the power increased anywhere from 30 per cent. to 50 per cent. The old common form of dies referred to was in very fair condition, the 1-inch die being particularly good. It did not cut down to gauge, and its record consequently is rather low. The results of the tests are given in detail in Table 8 and a summary is given in Table 9.

TABLE 8.

(I. C. S.)

PIPE TESTS. (Test pieces, 6 feet long; lever arm, 16 inches.)

Wrought Iron Pipe.

Dec. 5, 1905.

Size and number of samples.		Power to thread with rake die 16-in. lever. Lbs.	Power to thread with new square edge die. Lbs.	Power to thread with poor square edge die. Lbs.	Power to twist or split. Lbs.	Remarks.
½ in.	1	25	30	45	100	Split at seam.
	2	25	30	45	110-140	Started to twist; went 2 times (Max., 180 lbs.); no split.
	3	30	36	50	100-140	Two turns; no split.
	4	28	35	48	100-120	2½ turns; split at 120 lbs.
	5	27	35	58	100-140	1¾ turns; no split.
	6	25	30	50	105-120	One turn; split at 120 lbs.
¾ in.	1	50	55	70	140	Split at stillson; no twist.
	2	42	50	73	140-200	¼ turn; split at vise.
	3	45	52	76	160-210	One turn; no split.
	4	43	50	75	150-200	¼ turn; split at stillson.
	5	40	46	70	140-200	½ turn; split at stillson.
	6	50	55	70	150-180	Split at vise and broke off.
1 in.	1	60	100	115	280-360	Split at ¼ turn.
	2	55	110	120	270-330	Split; did not twist.
	3	65	105	120	280	Split at once.
	4	60	110	122	270-330	Split; did not twist.
	5	65	115	120	260-300	Split; did not twist.
	6	70	105	123	280-360	Split; did not twist.

Mild Steel Pipe.

Dec. 5, 1905.

½ in.	1	30	60	65	180	1½ turns; split at end with stillson.
	2	40	60	63	100–200	Twisted 2 times; no split.
	3*	30	36	48	100	Split at 100 lbs.
	4	38	55	58	110–125	Split at 125 lbs.
	5	30	50	56	100–125	Twisted one turn; no split.
¾ in.	1	45	60	100	150–240	1 turn at 220 with no split; 2d twist split at 240 at vise and stillson.
	2	45	60	88	130–210	1 turn; no split.
	3	42	57	85	150–220	1 turn; no split.
	4	45	65	90	170–240	1½ turn; no split.
	5*	32	47	75	140–215	Split at ½ turn at 215 lbs.
	6*	43	55	80	100	Split at vise ½ turn.
1 in.	1	72	130	160	280–440	¾ turn; no split.
	2*	70	100	120	280–400	½ turn; flattened and split at stillson.
	3	62	105	140	350–440	Opened at stillson and vise; OK. at 400 lbs. 1 turn.
	4*	60	95	110	270–440	½ turn; no split.
	5	80	110	100	240–360	Twisted ½ turn; no split.
	6	60	110	100	280–400	¾ turn; no split.

* Galvanized wrought iron.

TABLE 9.

(I. C. S.)

APPROXIMATE POWER REQUIRED (POUNDS) TO THREAD, TWIST AND SPLIT PIPE.

SUMMARY.

Kind of pipe.	To Thread; well oiled; steady pull at 16 inch leverage on die-stock arm. New rake dies. Lbs.	New common dies. Lbs.	Old common dies. Lbs.	To Twist. Steady pull with stillsons. Lbs.	To Split. Steady pull with stillsons. Lbs.	Margin of safety. Lbs.
½ inch Steel (4 samples)...	34.5	56.25	60.5	122.5	152.5	73.85
½ inch Iron (7 samples)....	27.14	33.14	49.14	102.14	110.	46.12
¾ inch Steel (4 samples)....	44.25	60.5	90.75	150.	240.	122.05
¾ inch Iron (8 samples)....	44.375	51.25	73.5	140.	176.43	80.88
1 inch Steel (5 samples)....	68.8	111.	124.	286.	420.	258.8
1 inch Iron (7 samples)....	62.14	105.7	118.57	272.85	326.66	172.52

The margin of safety column at the right hand side of Table 8 is compiled by adding 30 per cent. to the power required to thread with old dies and subtracting the sum from the power required to split the pipe. If the mechanic pulls on the dies beyond that limit, due to dull and imperfect dies or due to a hard spot in the pipe, he certainly will, according to the nature of things, split the pipe. Or, if the power required to split is nearly the same as the power required to thread, as is the case in the last sample of ¾-inch pipe in the mild steel list (which, on test, proved to be ¾-inch galvan-

ized iron), then the pipe will certainly split through no fault of the mechanic, but through defective tools combined with a quick, jerky motion which the men must put on the dies if they are going to hustle along the work. With dies having the proper rake there would be no danger of splitting this pipe while threading it. Fig. 11 shows the wrought iron pipes after the International Correspondence Schools test, the steel samples being shown in Fig. 12.

In making the torsion tests, we had to screw up the vise tightly to prevent the pipe turning, and this tended to crush the pipe and start the seam. The effect of gripping so tightly was quite noticeable, for most of the splits started at the vise. The galvanized pipes were more difficult to hold than the black iron because the galvanizing coat filled the teeth of the vise and somewhat prevented their gripping properly into the solid metal. In some of the samples we had to apply a stillson to help the vise, allowing the arm of the stillson to rest on the 4-inch by 4-inch timber to which the spring balance was hooked. In spite of the fact that the crushing effect of the vise and stillson was much greater on the steel pipe than on the wrought iron pipe, and the steel pipe seams were consequently much more weakened by the application of these tools, still it is noticeable that more power was required to split the steel pipe than the wrought iron pipe.

It is also noticeable that the margin of safety for the steel pipe is much greater than that for the wrought iron pipe, and it seems rational to assume that the trade must experience trouble by wrought iron pipe splitting at the vise as well as steel pipe. Judging by the tests, it is evident that common steel merchant pipe will ordinarily twist before it splits and that common wrought iron merchant pipe will sometimes do the same thing, but the iron will not twist as much as the steel and requires on an average less power both to split and twist. However, in wrought iron this weakness is somewhat compensated for by the smaller amount of power required to thread.

It will also be noticed that by the use of old square edge dies, particularly if the dies are very dull, it must be expected that both wrought iron and mild steel pipes will be occasionally split through no fault of the mechanic. It is also noticeable that the rake dies, even if run dry and in quick jerks, will keep well within the safety limit for common merchant pipe and should prevent split pipes.

My opinion of the entire case, independent of all outside in-

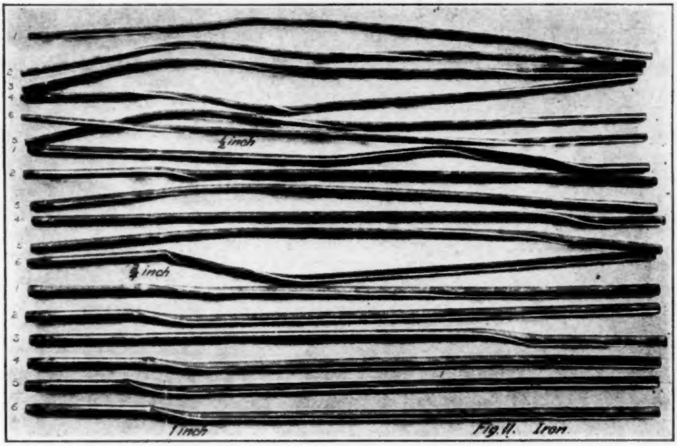


FIG. 11.

fluences, is that correctly made dies are a step in the right direction and that die makers should make all their dies with a rake that is best adapted for threading both wrought iron and mild steel pipes, and with sufficient relief to reduce friction. To offset this, as an inducement for manufacturers to ease up in their inspection, testing, and culling out of the poor pipe at the mills, I would suggest for your consideration the preparation of a stand-

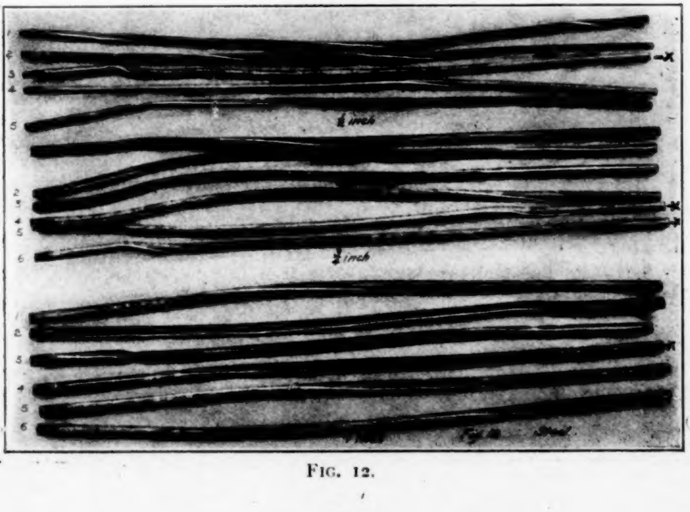


FIG. 12.

ard torsional test that any intelligent mechanic can easily and quickly apply on a job to any length of butt-welded pipe, with the object of determining whether or not the weld is sufficiently strong to warrant its use in a building. I do not see why this cannot be done without materially increasing the cost of a piping system.

The perfection of the weld in any length of pipe, as I understand the matter, depends almost entirely upon the care, precision and alertness of the man who operates the welding furnace. If he is not competent or is neglectful of his duty, whole car loads of poorly welded pipe may get on the market unless, of course, pipe manufacturers apply torsion tests. As I see the matter at present, I believe the correct way to get the most accurate results, as far as the weld is concerned, is for the pipe manufacturers to scheme up some way of applying what may be called a hydro-torsion test.

It appears to me that the solution of the split pipe trouble is a kind of family affair on the cooperative plan, in which pipe manufacturers, die manufacturers, and the masters and journeymen of the plumbing and heating trades are all concerned. To insure a complete success, the duties of the cooperators may be as follows:

The pipe makers must all test their pipe, not only for leakage, but also for strength of seam to resist splitting during threading and bending operations. The die makers must all fall in line and make the future dies with a correct rake and relief, so that the mechanics will not have to wear themselves out pulling 100 pounds when a 50 or 60-pound pull will do the work, and particularly when properly formed dies will wear better and longer than square edge dies. The master plumbers and fitters must all get their old dies fixed up or get new ones of the correct form, and keep them fixed up. And the journeymen have their share of the responsibility also in that they must see that good dies receive good usage and are liberally fed with good lard oil. As soon as a die becomes dangerously dull, it is their duty to refuse to use it any more until sharpened again. If all these interested parties were to enter into the spirit of such a movement, split pipe would soon be a thing of the past.

Gentlemen, these are my opinions of a matter which at this present moment is exciting the interest, and in some ways aggravating the passions, of many members of the heating and ventilating trade. I have tried to get at the truth. I have tried to look

at the matter from a disinterested point of view. If I have failed to reach the facts, then I would like to be set right. I have not considered whether wrought iron as a metal is better than mild steel or whether mild steel as a metal is better than wrought iron; I have not made any reference to the durability of wrought iron pipe or of steel pipe; I have simply confined myself to the one topic of dies and split pipe.

Regarding the durability of wrought iron and steel pipe and the uses to which these pipes may be applied to the best advantage, I believe that a great deal has yet to be learned, and it is the duty of this society to find it out. I believe that most of the pipe on the market to-day is soft steel pipe. I know that a large amount of pipe has a very short life. Many in the trade claim that steel pipe is not so durable as wrought iron; others claim the opposite, and many have not noticed any difference. For my part, I have noticed that very few can actually distinguish between the two. I have flattened and broken up pieces of both wrought iron and mild steel pipes and have asked heating contractors, journeymen fitters, and the men at the threading machines which of the broken up samples were wrought iron and which were mild steel, with the almost invariable result that they did not know. In the face of this condition, it is not safe to go by opinions. As the durability of the materials composing the body of any structure is the most essential feature, and as piping constitutes the greater part of the structures erected by the members of this society, I believe that the matter of durability of wrought iron and steel pipes should be carefully investigated and the truth recorded for the benefit of the architects, engineers and pipe consuming public.

Talking about this now after having said so much about the correct form of dies to cut and thread pipe may appear like putting the cart before the horse, but the fact is that an investigation into the relative merits of wrought iron and modern mild steel pipe is a work altogether too prodigious for one man; it requires the cooperation of an entire body of men, such, for example, as the American Society of Heating and Ventilating Engineers.

DISCUSSION.

Secretary Mackay: I have listened to the paper with a good deal of interest, because in my earlier experience the first thing

they put me at was to cut pipe, and in the daytime we had to cut it with a screwing machine that ran by power and at night-time I had to be the donkey power. At that time we used wrought-iron pipe. I do not think steel pipe was known. We had a good deal of trouble with the dies. The dies were something after the type shown in Fig. 2 and were solid dies, and more often split the pipe in reversing and backing out than we did in cutting the thread. To prevent loss we used to have the dies re-cut, but found they never were uniformly-tempered afterward. It was almost a waste of time and money. The trouble seems to be that there has not been any improvement in the manufacture of dies for cutting pipe from that time—thirty-five years back. There was a patented die on the market that had some points of advantage over the straight cut, plowing, cold chisel or planer movement, shown in Fig. 2, or shown in a worse condition in Fig. 3, and perhaps in a little better condition in the last *b* in Fig. 3. But all of them came against the weld of the pipe as Mr. Thomson has shown. The weakness is in the weld, and if that cannot be eliminated in the construction of pipe then there is an opportunity to improve on the cutting tools, so they will not split the pipe at its weakest point. The trouble is usually in handling and placing, and is sometimes due to imperfect weld at the mill, but I have seen more pipe split by cutting it with imperfect tools, threading with imperfect tools and placing it at too great a distance from the holding point of the vise. On Fig. 5, while it looks fairly close, that is further away from the holding point than I would care to have anybody do it for me without feeling they were going to go into my pocketbook by splitting my pipe. And when we come along to Figs. 6 and 10 it shows 15″ to 18″ from the vise to the die. You take a poor die that is going to strain the weld and then hold it so far away there is nothing to do but split the pipe. So that I believe that poor tools better used would obtain better results in the way of threading a pipe in the position it was intended to be than as shown in Figs. 5, 6 and 10. It seems to me that while this may not be a fair test, what we need is, first, better cutting tools for cutting off and threading and then greater uniformity of pipe. If possible, there should be greater strength of weld, whether iron or steel, butt or lap welded. The particular type of die I have reference to cut on an acute angle, with never more than one tool on the

weld at one time. The first tooth had passed the weld before the next was reached, etc. The average workman who understood his business and knew what he was doing and knew what would split the pipe and not split it obtained good results. But the majority of dies, as I know them, are the same old dies we used thirty and thirty-five years ago, with no improvement at all in their shape or design. The only thing that they have done has been an endeavor to cheapen them, and, consequently, make them correspondingly poorer.

President Kent: We would like to hear from a representative of the die-makers.

Mr. H. H. Walker: This matter of dies has been of very great importance in our factory. We have kept at it for twenty-five years to see if we could produce something that would handle all classes of pipe. The great trouble with us has been that the pipe, as it appears to us, in coming from the roller is very apt to strike moist ground or a water puddle which puts a scale on the surface of the pipe, and when it comes in contact with the die it is so hard it chips and breaks the die away. I have listened with a great deal of interest to Mr. Thomson's opinion as to the grade necessary in the cutting, and the position of the die as shown in Fig. 4 is the one that corresponds almost exactly to the method in which we are making our die to-day. So that we feel our die is really up to date.

President Kent: Is there any difference in the die's work on wrought iron or on steel?

Mr. Walker: The wrought iron is very much easier to cut and the scaling is not so severe.

President Kent: Don't you find any wear in the die in cutting wrought iron?

Mr. Walker: No, sir; not perceptible.

Mr. Howe: All I care to say is that all our tools are made with perhaps more than the 20 per cent. angle Mr. Thomson spoke of. I was interested in what the Secretary said about having but one tooth at a time on the weld. We have got over that, but we may have other troubles, but we feel it is not quite so necessary.

Mr. Barron: The form of the die is not everything. The important point is the steel of the die, and the great trouble with die-makers is to get proper steel. That is as important as the

form of the die. The form is important, but the more important part is the tempering of it. I ran pipe machines in Philadelphia when a boy, and we didn't have any more trouble thirty-five years ago than we have to-day. We used nothing then but the solid die. Of course the shop has a good deal to do with it. You know, if you were at a lathe I would prefer one machine and you would prefer another, and yet all would produce good results, being all good workmen. It doesn't seem to me they are to-day turning out any better dies than they did thirty-five years ago. I bought a die of Mr. Walker sixteen years ago, a Chaser die, and that machine was an excellent machine.

Mr. Walker: I think Mr. Howe will agree with me that in the pipe machine manufacture of to-day it is not the trouble of the die but the trouble of the man into whose hands the machine is placed. The machines are made to operate in a perfect manner. The average man who gets hold of a machine doesn't give it any attention. He cuts the pipe, and when the whistle blows drops the wrench or whatever he may have and scoots out of the building. Possibly he goes on to some other class of work in the afternoon. The machine stands. Another man comes, leaves the chips in the machine and he goes off. Nobody is responsible for the care of the tool. The master mechanic and master steamfitter should insist that the men keep the tools clean, as we do in the factory. A pipe-threading machine is a machine and must be kept clean, and if kept in proper shape there is no reason why it won't work and work perfectly. We have troubles, of course, but every time I have gone to see why the machine was out of order invariably it has been because the machine was so stuck up with chips and oil it was impossible to operate it. It is a matter of dirt. If greater care were given to cleanliness of the tool I think there would be much less trouble in the matter of threading pipe. We never have any trouble splitting pipe that I know of with our machines, and I think we have kept pace with the pipe makers. We correspond with the pipe mills to know what they are going to do, whether they have changed the metal, and we change the dies accordingly in the matter of temper. We are not asleep but awake.

Mr. Gormly: I think this is one of the best papers ever presented. It comes right down to the facts. In our shop we have found trouble with dies, pipe frequently cutting like glass. Pipe

we buy for iron is steel and some we buy for steel is iron. We have had pipe that had no hole through it, and we have found a diaphragm in pipe as though a slab of steel or iron had peeled off and welded crosswise of the hole. We have had dies, buying them perfectly new, cut one thread with them, and they would be as flat as the end of a lead pencil—absolutely not tempered or imperfectly tempered.

Then, of course, we are up against ignorance. While there is much to be said against the material we get in the pipe and the material in the dies and the form of die, there is still something to be said against the ignorant handling of them. I think a little original thought and a little more care on the part of the manufacturer to get good material in his pipe would remove some of the trouble. We have found pipe after we had it in place would snap off like glass, and the material in it would show crystals as though tempered. That kind of thing is unsafe, and I really think there should be municipal control of steam goods, because some of the pipes used are absolutely dangerous. There should be some kind of test, I think, in the various societies as to what grade of pipe will be tolerated to be used at all. This paper brings out clearly the advantage of working in harmony and shows us what associated action can do in the direction of improving pipe and dies. We have dies we are using now, and one man will cut a 4-inch pipe with greater ease than two years ago he could cut a $\frac{3}{4}$-inch pipe. There is that difference between the pattern of dies we now use and those formerly used.

Mr. Donnelly: I want to ask if in actual practice where the pipe split was the pipe held an unusually long distance from the die? Of course, the power required to both twist and split the pipe would vary as the length of the sample tested.

I, therefore, do not think that Table No. 8 is correct in the "margin of safety" column. The power required to twist and split was taken on pipes held about 6 feet between gripping points and the power required to thread on 12 inches to 18 inches. The power required to twist and split would have been greater if tested between the shorter gripping points that were used to thread and this would have made the margin of safety greater.

In connection with mechanics' use of dies the question sometimes is, "What is the best way to catch a solid die?" and among the answers is, "To file a flat place at the top and one

at the bottom." Another is, to oil the end of the pipe. I have known a man who could not catch a solid die to throw sand into it. I remember a man I worked with when I went out helping in New York City whose practice was to file the top and bottom, wipe off with waste and then take a piece of chalk and chalk it carefully all around, and if he couldn't catch it then he would pour oil on and wipe it off again and use more chalk. He couldn't catch it one day and gave it up—said he had a very bad die; he wanted a new one. When he was off taking a rest I oiled it up and caught the die. I always oiled the end of the pipe on the supposition that if the die did start the chip was not as liable to break off when oiled as if it had sand or chalk. Workmen will have their notions. One favorite trick is, if a die pulls too hard, to take it out and break it. I have seen a man go to a quiet spot and take a cold chisel and hammer and break out all the teeth.

Mr. Quay: The great difficulty we found after steel pipe came into use was that frequently the steel was harder on one side than on the other. We found sometimes it was thinner on one side than on the other. The main difficulty with the steel pipe was where we found these conditions, and very often we would have to send the pipe back. We found after trying a few pieces they were so defective it didn't pay to use them—it wasn't safe. We got on jobs where we could order our pipe in advance, buy wrought-iron pipe from the mill direct, where we knew they made wrought-iron pipe only, and we found it paid even if we paid more for it. We saved more time in the cutting than the difference in cost between wrought iron and steel pipe. All these difficulties mentioned about men being careless about the dies, etc., are true. It is very difficult, indeed, especially in this age, to get men as you hire them who will take proper care of the tools. We found, in addition, the expense of keeping up the tools to cut steel pipe was something enormous. It seemed every day we would have to get new dies, so the men could not make any time in cutting. I am very much pleased with this paper. I think it is one of the best papers we have had. While the question of the die seems to be an excuse for a poor quality of pipe, I do think the best dies we could get are what we should have, and I disagree with the speakers that there is no improvement in dies, for I know there is. We have quit using some dies, and use special dies in order to make progress. I think pipe manufactur-

ers need to be pounded at—if they are going to use steel pipe—until we can get a better quality of steel, uniform in thickness and in temper, than we find in merchantable pipe.

Mr. F. N. Speller, M. E. (Metallurgical Engineer of the National Tube Co.): There is usually something to be gained by engineers connected with the manufacturers' and consumers' interests taking up together such a subject as Mr. Thomson has so ably put before this Society to-day. For that reason I appreciate your courtesy in extending the privileges of the floor on this occasion. We are always glad to welcome such a thorough and painstaking investigation as Mr. Thomson has made of modern pipe material. Of course, the process of making pipe steel did not reach the satisfactory state of to-day at once. It is now twenty years since the first steel pipe was made, and in that period much experimenting had to be done. By making this special soft steel with the highest degree of weldability in view and adapting every detail to this end from the ore to the finished pipe or tube, the result is a much more pliable and uniform pipe, better adapted to the numerous uses to which pipe is now put, and with the additional advantage of cheapness compared with wrought iron. The tests suggested and worked out by Mr. Thomson bring out the greater strength of the welded steel seam better than any experiments yet made, but such a twisting test as he suggests would be difficult to apply in the mill. We find it pays to be strict with the testing and take every precaution, so that all pipe is tested to 600 lbs. per square inch, and some much higher when specified.

As manufacturers of our own dies and users of the same, we can corroborate Mr. Thomson's conclusions that it is just as easy to thread steel as iron when the die teeth are given a proper rake and are slightly relieved. This also gives longer life to the die and produces a cleaner cut thread.

The making of threaded joints is probably the most important detail in pipe work, and one in which considerable economy can be practiced when all dies are made with due regard to these principles. The only explanation I can offer to the question you ask, Mr. Chairman, as to how "Steel Pipe" could be hard on one side or surface hard as described by a gentleman this morning, is that the pipe in question was made of a cheap iron composed largely of odd steel scrap which may be hardened by water cool-

ing. National pipe steel resembles iron in that it is unaffected by quick cooling; this, together with its high welding qualities and ductility, puts it in a class by itself, and it can be called steel only in the broadest sense of the word. To meet competition iron has undoubtedly been made by some of steel scrap, and such material has given much trouble with the dies and in splitting, which has been to my personal knowledge in many cases credited to steel. Such experiences can be minimized, if not entirely avoided, by using genuine soft steel pipe and paying due attention to the shape in which your dies are ground.

Mr. Thomson: I have brought here a few samples of wrought iron and a few samples of steel pipe, showing the characteristic fractures of wrought iron and steel, which the members can examine.

CLVI.

SIZES OF RETURN PIPES IN STEAM HEATING APPARATUS

BY JAS. A. DONNELLY.

(Member of the Society.)

It seems a very singular fact that while many papers have been written upon the sizes of steam mains and a quite elaborate treatment of the same subject is given in the works upon steam heating, that return pipe sizes have been so lightly passed by.

Without a single exception, as far as the writer has been able to discover, the text books have given a rule of thumb for determining the sizes of return pipes, stating that the return main must be made much larger than that necessary to carry the water, as there was an indefinite amount of air to be provided for.

Before presenting any method of proportioning return pipes it will be well to state as clearly as possible the exact functions of a return pipe, taking as an example the most difficult of return pipe problems, the dry return for an ordinary gravity return boiler system.

It seems quite clear that the function of the steam main is to carry the steam to the radiating surfaces with as low a loss in pressure as practicable. This is for two reasons: first, that the radiator may be very near the temperature of the steam in the boiler and its efficiency consequently as high as possible; second, that the loss in pressure due to friction shall not be greater than that which can be restored by the available static elevation of the steam main above the water line of the boiler. The return main, which, as before stated, is considered to be a dry one, must not only return the water of condensation to the boilers, but must carry back to the water line of the return where it drops to the boiler and becomes a wet return, the steam necessary to supply the radiation of the return itself,

without such loss in pressure as, added to the loss in the steam main, will be more than the before mentioned static head available between the water line in the returns and the water line in the boiler.

In other words, the dry return is essentially a steam carrying main, and the large size that is necessary in it is due solely to this fact and not to the air which may be in it, for if the air is an obstruction it should be removed by an air valve.

In a paper read before this society by J. J. Blackmore, an expression was used that has been common in the trade: in speaking of the return pipe he said that "the return must be large enough to equalize the pressure in the system." This statement is a great improvement upon the others referred to, even though it may not be exactly correct.

There are, generally speaking, three classes of returns for steam-heating systems, and as their different functions create different conditions they must of necessity be considered separately.

First, the wet return, where the condensation is carried as much as possible below the water line of the boiler or return tank, or sealed by establishing an artificial water line.

Second, the dry return in a gravity return apparatus, where the water is carried above the water line, and in a wet return system that part of the return which is above the water line of the returns.

Third, the return of what for want of a more exact classification is called a high difference in pressure system, where the pressure carried is either considerably above atmosphere and the air, water and steam from the return are usually discharged into a vented tank, or where the pressure is substantially atmosphere and the returns are carried in a pipe in which a lower pressure is mechanically maintained.

Considering first the wet return as the most simple form, there is no question but that it has only one function to perform, namely, that of returning the water of condensation.

In a paper presented last year it was recommended that the steam mains should be so proportioned that the drop in pressure should not be more than one ounce in one hundred feet run of straight pipe and, figuring the carrying capacity of wet return pipes for the same drop, their size for steam mains of

the capacity given is shown in the annexed table. No allowance has been made for the extra amount of condensation due to heating up the apparatus, as this is usually spread over a sufficient time to allow the water to return without flooding the steam mains. It will be seen from this table that the diameter of the return mains is one-quarter that of the steam mains and their area one-sixteenth. This rule will give the results figured for wet return sizes if air traps and mechanical obstructions in the pipe are avoided.

When carrying capacity	286 sq. ft.	535 sq. ft.	890 sq. ft.	1,950 sq. ft.	3,600 sq. ft.	5,900 sq. ft.	12,700 sq. ft.	22,900 sq. ft.	37,000 sq. ft.	55,300 sq. ft.	78,300 sq. ft.
Size of steam main is....	2 in.	2½ in.	3 in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.	14 in.	16 in.
Size of wet return........	½ "	¾ "	¾ "	1 "	1¼ "	1½ "	2 "	2½ "	3 "	3½ "	4 "
Size for 10% of steam.....	1 "	1¼ "	1¼ "	1½ "	2 "	2½ "	3½ "	4 "	5 "	6 "	7 "
Size for dry return.......	1¼ "	1½ "	1½ "	2 "	2½ "	3 "	4 "	5 "	6 "	7 "	8 "
Size for vacuum return...	1 "	1¼ "	1¼ "	1½ "	2 "	2 "	2½ "	3 "	3½ "	4 "	5 "

Where returns are placed above the water line it is of course impossible to keep them full of water, due to the fact that they are seldom working to their full capacity and that their tendency to fill is immediately checked by the increased velocity due to rise in static head. The space unoccupied by water is therefore filled with steam, and as it is not possible even in a horizontal dry return pipe to heat only a portion of it, the space for the transmission of the steam must be large enough to supply the steam necessary to heat the entire pipe.

The sizes given in the table as being necessary for the water only are about one-half the diameter and consequently have about one-half the superficial exposed surface of the sizes usually employed. It has been found by figuring the surface of the returns in a number of average house installations that it will amount usually to about one-tenth the surface of the radiators; assuming this to be true, or assuming that the extra size of piping called for by the heating of the return main will about double the exposed surface, the next row of sizes in the table is obtained, namely, the size of pipe necessary to carry one-tenth the amount of that carried by the corresponding steam main. The combined area of the two as given in the

next line is, as will be seen, the size for dry return usually recommended.

There is, however, a possible reduction in size when the return mains are covered. If they are covered so that their radiation is cut down to from 25 per cent. to 50 per cent. that of bare pipe, the demand for steam is proportionally less and their size may be reduced accordingly.

The foregoing data seem to furnish a sufficient reason why the present sizes of returns have proven satisfactory, and yet it is not correct except for the smaller sizes of return mains, or those portions nearest the radiators. For as the return approaches the boilers the amount of steam to be supplied to it constantly decreases, and if the steam main is 6 inches and the corresponding size necessary to carry the water $1\frac{1}{2}$ inches, assuming the return 150 feet long and figuring 2-inch pipe as perhaps large enough for carrying both steam and water; 150 feet of 2-inch pipe has about 100 feet of heating surface, and this added to the capacity of the pipe necessary for water shows that a 2-inch pipe is ample for the purpose, instead of a 3-inch as generally used.

Again figuring a ten-story steam riser 3 inches in diameter, supplying 900 feet of surface, the return for water would be $\frac{3}{4}$ inch; if it fed a dry return the amount of surface in the main return would have to be figured in determining its size, but if it was dropped into a wet return or sealed and a wet return established, the return riser would only have to be large enough to carry the water and supply itself with steam. Of course in vertical pipe, one even smaller than $\frac{3}{4}$ inch would drop the water ten stories; but assuming that it was 150 feet high and it was made 1 inch it would contain only 150 feet of surface and would seem to be large enough; certainly $1\frac{1}{4}$ inch would be ample.

It would therefore seem that the experiments and observations upon return pipe sizes have been made principally upon dry return systems and radiator connections, and the rule thus established applied to all systems and sizes.

A sort of a paradox that the larger the return mains were made the larger they had to be, and the smaller they were the smaller they might be, would be established were it not remembered that the capacity increases faster than the area, which

varies proportionally as the square of the diameter, and the exposed surface only directly as the diameter.

The drip from the steam to the return main is another factor that is the cause of much trouble; for as there is always a higher pressure in the steam than in the return main at any drip point, caused by the loss in pressure in the mains beyond that point, the drip pipe conveys steam as well as water and a counter flow is set up in the return main.

A strange condition sometimes exists in dry return main systems when all or nearly all of the radiators are closed; for if those are left open or the drips are not large enough in effective area to keep the pressure in the return sufficiently high, the return main will be flooded and a very puzzling situation developed. This has led to the practice of connecting all steam and return risers upon the upper floor by a direct pipe, or connecting the ends of the steam and return mains where the counter flow, if any, will be up the return riser only.

Passing now to the class of systems called the high difference in pressure systems and considering their sizes of returns. The steam main has been cut down very materially in both subdivisions of this class, at some considerable sacrifice of efficiency of radiators. Many times an initial pressure has been reduced several pounds into the radiator at a loss of temperature of about 4 degrees for every pound drop.

In the systems working above atmosphere and discharging into a vented tank, the returns have very often been tried as a carrier not only of the water and air and the steam required for their own heating, but for the carrying of a large quantity of steam blown up the vent pipe. Systems of this class should undoubtedly have traps upon the radiators or in the branch returns, as from the complicated nature of the figuring involved it is practically impossible to correctly proportion the sizes of the return pipes.

The sizes of return pipes for vacuum return systems were given in a paper read before this society by R. P. Bolton. They were approximated by combining the areas of the discharge passages through the automatic valves. These sizes were somewhat changed in a revision of the paper recently published, in which it was stated that the return should be one-tenth of a

square inch in area for each 100 square feet of heating surface supplied by the steam main.

In the Plumbers' and Fitters' Pocket Book the sizes of vacuum returns are given very much the same as in the table for those necessary for the water only. These sizes correspond to steam sizes which run as high as 160 feet a second velocity for a ten-inch pipe, for runs up to 400 feet, and are apparently figured for a one-pound drop for that distance in straight pipe. The sizes of returns given would probably cause three or four times that drop, especially if the steam mains were carrying the radiation tabulated for them; which is about double that carried in gravity systems.

Applying the rule given by Mr. Bolton to the steam table as rated in the P. & F. P. B. would give an 8-inch return for a 10-inch steam main instead of a two and one-half inch. Applying it to the smaller sizes of steam main, it gives about the same size return as for gravity systems.

The sizes of return pipes for vacuum return systems can only be figured when the amount of steam drawn into them is known. As usually proportioned their superficial surface will average very much the same as gravity systems—about ten per cent. of the radiating surface.

Of course it is very apparent that if no steam was passed by the automatic valves a very low vacuum would be produced without jet water at the pump. Each square foot of condensing surface in them would only have to radiate 180 B. T. U. to reduce the water to the temperature of 22 inches of vacuum (153 degrees), and the return surface at this temperature would easily have an efficiency of that amount.

Where but a moderate vacuum is produced, with uncovered returns and the use of a reasonable quantity of jet water, it is certain that twenty to twenty-five per cent. of the steam carried out through the steam main is brought back through the return main. In that case the returns would have to be figured large enough to carry the water and that amount of steam with a reasonable drop in pressure.

With several different styles of automatic valves upon the radiators and the returns grouped and carried through controlling devices that gave a low and uniform differential throughout the installation, it has been found possible to with-

draw all the air as it accumulated and to keep the steam down that was drawn into the return, so that it did not exceed three per cent., and the branch returns up to the differential valves have been figured to carry the water and that amount of steam, the returns from the differential valves to the pump being figured only large enough to carry the water with a reasonable allowance for air and re-evaporation.

Summing up the results of this study of pipe sizes it would seem:

That general practice often makes the steam mains too small, especially where allowance is not made for the drop in pressure in the return pipe.

That it is impossible to figure return pipe sizes for corresponding sizes of steam mains until some agreement is reached as to the uniform rating of steam mains. A general rating of steam main sizes should be adopted on the ground that efficiency of radiators should not be sacrificed where the run is short; because it is not practicable to carry steam 500 feet without say 2 or 3 pounds' drop, is no reason why small pipe should be used upon short runs in order to get this drop and inferior efficiency of radiating surface be obtained unnecessarily.

That wet return sizes and dry return sizes, where they connect to wet returns, have usually been made unnecessarily large.

That dry return systems are usually made worse rather than better by extra large sizes of return pipes, and that the main return may be made smaller, especially where it approaches the boiler.

DISCUSSION.

Mr. Quay: In reference to the size of the return pipes, especially the risers, for a 3-inch steam riser there is used a 2-inch return pipe, and for a 2½-inch riser there is a 2-inch return pipe. Why is this? Can any one give me the difference between the amount of steam and the return, how much it will be reduced in quantity and go back in the return as water? Why do we use these sizes? I would like to know. I do not know any reason why. I cannot understand why it is done. If any member can inform me as to that I will be very much delighted.

Mr. Barron: This question of the size of the return pipe was taken up some years ago in our earlier meetings and discussed by Mr. Quay, Mr. Hopkins, Mr. Wall, and, I think, Mr. Baldwin. The problem was considered this way: A cubic inch of water evaporated into steam gives a cubic foot of steam, and, logically, for that reason making the return riser just one size smaller than the steam riser, was ridiculous. I have always advocated smaller return pipe. Mr. Quay said that the average consulting engineer, specifying the gravity system particularly, will specify the return shall be one size less than the steam riser. All return risers in all return systems are too large; excessively large; unnecessarily large. Mr. Hopkins, I believe, said the return mains would fill up with sediment and we should make the pipes excessively large for that reason; that the sediment that ordinarily is deposited in the boiler was not blown out and would in time fill up the return pipe, and they should be proportionately large to cover that condition. I think Mr. Donnelly's paper is an excellent paper and the question should be agitated. There are other reasons why a 2-inch return pipe should go with a 3-inch steam pipe, for a $1\frac{1}{2}$ inch or a $1\frac{1}{4}$ inch looks out of proportion.

Mr. Harding: Mr. Donnelly said the size of the return pipe was governed not only by the fact you had to return water, steam, and air and all that sort of thing back to the boiler, but you had to return the pressure back to the boiler. If you reduce the return pipe you have a much reduced steam main and consequent difficulty throughout the system. In other words, you don't get pressure back to the boiler.

Mr. Bolton: My basis, if taken as stated in the table, will, I think, give ample return sizes even for gravity systems. Many points in the paper are undoubtedly good as bearing upon this general subject, and it must be admitted that we have not thoroughly established what is the best proportion for return mains under the very variable conditions in different heating systems. There is a great deal more difficulty in establishing conditions for return mains than for supply mains.

Mr. Quay: The only answer to my question seems to be in order to get pressure back to the boiler the returns should be large. I don't think that answers the question satisfactorily. I would not advocate using a $\frac{1}{2}$-inch return pipe on the gravity system. I spoke of a 3-inch steam riser and $2\frac{1}{2}$-inch return, and a

$2\frac{1}{2}$-inch riser and a 2-inch return. The question of using these large return risers in order to establish the pressure on the boiler is ridiculous to talk about in this age. We find in nearly all cases these are wet returns. As far as economy is concerned in heating a building, the principle is to condense the steam in the radiator, and not to have the steam travelling through the radiator and through the return continuously, but condense it at that point and have your return large enough to carry off condensation, and there is no more use in using a 2-inch return riser for a $2\frac{1}{2}$-inch steam riser—no reason on earth for doing it. It is simply because these engineers have been in the habit of doing it, and they don't want to change the custom. You cannot figure it out from any scientific principle why you should simply have return risers one size less.

Mr. Gormly: We do make mistakes, and it is a wise thing to make them on the right side. I didn't get an opportunity to pay very much attention to this paper when read and haven't read it. I don't know whether it treats of friction on horizontal runs of return mains. I think that is an important thing to be discussed, because very much depends on the grade of the main and the distance it is run horizontally. One reason why a small main should not work as well as a large one would be that the condensation would have a tendency to form globules on the return main. Probably that is one reason why a small main don't answer, whereas theoretically it may work all right.

Secretary Mackay: I know of a case, now some ten or twelve years ago, where a prominent contractor had placed two different apparatuses and I was called in. They claimed that the boilers were defective. In one case there was a 4-inch main (with two boilers), extending 100 feet either way, and they carried a 2-inch dry return back in under the steam main which dropped down at the boiler. They were troubled with water rising and filling up the end risers. I gave an opinion if they were enlarged to 3 inch it would overcome their entire trouble. They said if I would remain there until they did it they would do it. They did it in that building, also in another building, where the return was $1\frac{1}{2}$ inch, they enlarged it to $2\frac{1}{2}$ inch. In both cases, where the boilers were claimed to be at fault, the trouble was altogether in the ridiculously small size of the return mains as proportioned to the steam mains which the steam-fitter had put up.

I have a case in point now where an engineer laid out certain size steam mains and certain size return mains, which were sent to a contracting engineer. I was called in as a consulting engineer. He claimed three feet difference between the water line of his boiler and the extreme end of the main. I had a water gauge put on, and I found sixteen inches when no fire was in the boiler and no steam on, between the bottom of the extreme end and the water line of the boiler. As they increased the pressure in the boiler you could see the water go up the three-foot glass gauge until finally two-thirds of the steam main would be submerged. That was due, first, to too small a steam main, and, later, to too small a return main. I believe in that particular case, had the return main been the same size as the steam main, it would not have done any harm and it would have prevented all trouble.

There have been mistakes made in the sizes of return risers and there are often mistakes made in this way. I have found good mechanics unable to determine between a vacuum system of returns to a receiver and pump and a gravity system. I have gone over work with a member of this Society whose engineers did not discern between the one and the other, and the result was he had trouble on his gravity systems—not one but a dozen—and in a dozen cases when he enlarged his returns the steam mains were all right, it overcame any trouble.

Mr. Quay: If I said return mains, I am sorry. I didn't mean return mains. I think I said return risers. I agree with Mr. Mackay about return mains. That is a different proposition. It is only the return riser—the proportion between the steam riser and the return riser I was talking about.

Mr. Barron: I want to make the same correction Mr. Quay made. I made the same mistake. In talking, you are apt to get confused on a complex question like this. A paper of this kind should be accompanied by diagrams and drawings to make it clear and keep the point as simple as possible. Three years ago I put up a little job, a four-story building, 3½-inch steam main—I presume about 1,000 feet of radiation—and the ordinary standard type of boiler. The height between the water line of the boiler and the lowest point of the steam main was about two feet. The largest return was one inch. I wanted to experiment and prove for my own satisfaction that I wouldn't have any trouble

with a 1-inch pipe, dry and wet return, and all above the floor, readily got at. The returns were not sealed. At that point where we did get between the steam main and the water line of the boiler, static head, as Mr. Donnelly explained it, on one cold day we had trouble with the water backing up at that point and possibly sealed that riser with water. Two feet did not give us a static head as I understand it. It is an exceedingly complex question. Oftentimes it works all right and oftentimes it does not, and we are required to make alterations and pay for them.

Mr. Wolfe: There is one little point made by Mr. Quay that I object to, and that is condensation of steam at the radiator. One end would be steam and the other end hot water.

Mr. B. H. Carpenter: I didn't understand how Mr. Mackay's enlarging the return pipe worked out.

Secretary Mackay: The return serves not only as a waste pipe but to equalize the pressure, so there would be uniform pressure all around in the steam and return mains.

Mr. B. H. Carpenter: Won't that work in the steam line on the same proportion?

Secretary Mackay: The steam main was ample to supply the radiation, but the return line wouldn't take back the condensation and equalize the pressure at the extreme end of the steam main, and, as a result, the steam main was completely flooded as shown by the gauge. So you have your steam main here (indicating and using blackboard) and your riser there (indicating) and the drip pipe here (indicating) and it completely submerged the steam main. By equalizing the pressure you keep the water at the proper level, not only in the boiler but the entire steam system.

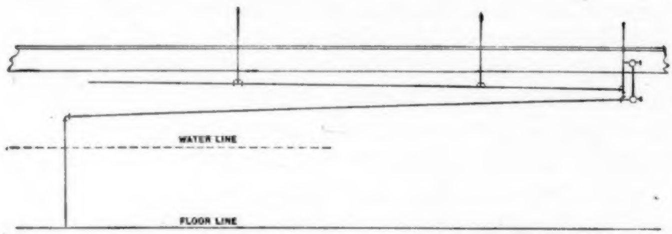
Mr. Quay: I said steam condensed in the radiator. Of course that is a general term. You know it is not all condensed in the radiator. It has to pass through the return unless you have an absolutely accurate valve of some kind that won't let steam pass through, but there is no necessity for making the return riser large to carry a large bulk of steam.

Secretary Mackay: This is the water line of the system when standing cold (indicating) and this is the steam end down here (indicating). The pressure was raised and this water gradually crawled up here. The pressure of the steam forced this water up into your radiators.

Mr. Carpenter: Was there any connection on the return pipe near the boiler?

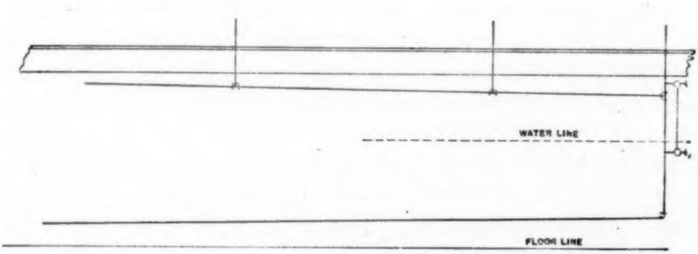
Secretary Mackay: Only the usual drips.

Mr. Carpenter: It is possible these drips were flowing into the return pipe and equalizing it in that way. By putting a larger



return you allowed the steam to go through the drip into the return.

Secretary Mackay: I put a gauge on a wet return—not the wet return in this particular case. The case I mentioned in Pittsburg was a dry return. The steam main this way (indicating) and the return main that way (indicating) and as the pressure rose this raised up (indicating).



Mr. Donnelly: In Atlantic City there was a man who said he could carry mains 250 or 300 feet and there would be exactly the same pressure 200 feet away as in the boiler. Everybody tried to convince him there would be a decrease due to friction.

The larger the steam capacity figured for the steam main the larger the return main. Figuring the return main on sizes given here, practically 23,000 feet, for a 10-inch main gives a 6-inch return main; you cannot get 23,000 feet in a 5-inch main; it would be 78 per cent. of 36, close to 24 or 25—say a 6-inch re-

turn. I don't think Mr. Bolton designed that rule for large sizes.

In regard to the sizes of returns, I am making it a practice to specify somewhat larger returns, especially in factory buildings where the size of the pipe is no detriment in the way it looks. Then it is stronger for people to run over it and against it. Mr. Gormly says a job is never spoiled by making the mains too large. That is true of steam mains but not of extra large sizes of dry returns. Dry return systems are made sometimes worse rather than better by large sizes. Mr. Mackay told me that story once before, and as I remember it he had 2,000 or 2,500 feet of radiation on a 4-inch pipe. There was a heavy drop on the main, which is an abnormal condition, and I think his remedy would be good in that case, but the correct remedy might not be in making the return main larger, but in increasing the steam main. I think Mr. Mackay has a tendency to make return mains as large as steam mains because he is a hot-water man.

Secretary Mackay: I have always felt that with the gravity return apparatus the return main should have some relative proportion to the steam main, and I have merely enforced my ideas in this particular case—and they accomplished the result.

CLVII.

A NEW VAPOR-VACUUM SYSTEM OF STEAM HEATING.

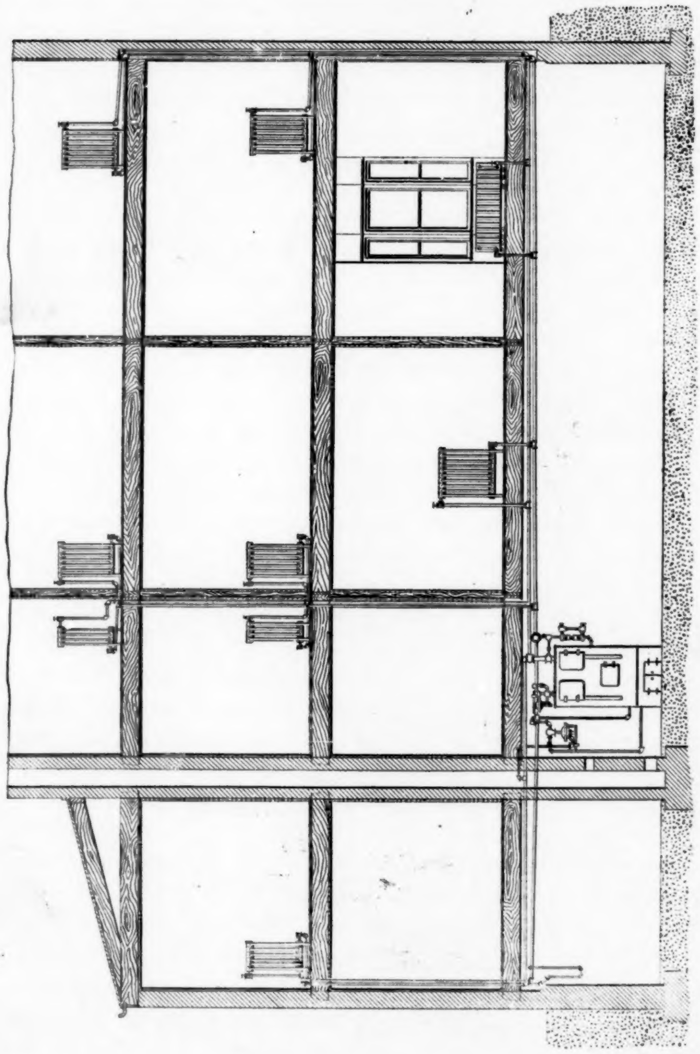
BY JAS. A. DONNELLY.
(Member of the Society.)

The system described in the following paper and illustrated in the accompanying cuts was designed to work under the same principles as those governing mechanical circulations, where a vacuum pump is usually used upon the main return.

It was believed that if correct mechanical devices were employed a gravity return system could be made to work in a similar manner to a vacuum exhaust system and with all the advantages of the latter. Chief among these might be mentioned the doing away with the automatic air valve, that most irritating and annoying of all contrivances, which is supposed to be a necessary evil in connection with each radiator; the practicability of graduating the inlet valve to secure a partial heating of the radiator; also the advantages of running the entire system upon a vacuum or at as high a pressure as might be desired.

Referring to the cut, it will readily be seen that the system is piped exactly the same, and with the same size pipes as any ordinary two pipe dry return gravity system. All moderate sized systems are piped in the manner shown, and where larger systems are installed the only change is to provide additional points of air removal and run a wet return system if desired.

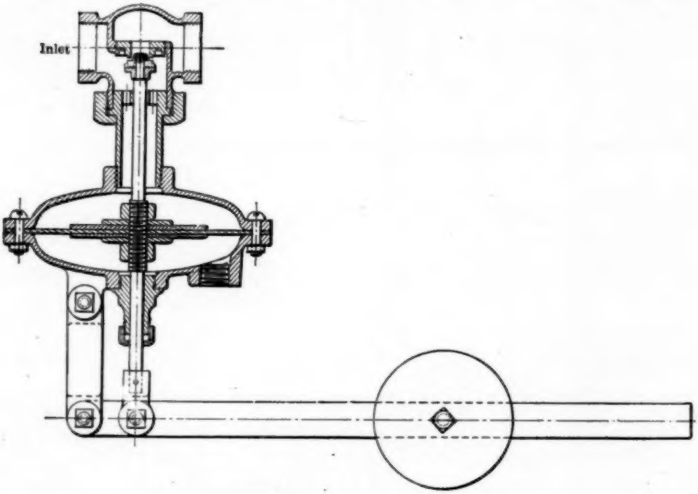
The hot water type of radiator is usually employed and the steam inlet is made at the top. No air valve is placed upon the radiator, as the air and water are both carried through the automatic drainage valve and down to the cellar. The water is then allowed to run to the boiler by gravity and the air removed by an automatic relief valve, located at the boiler in ordinary installations or at the foot of the riser or group of risers in large systems.

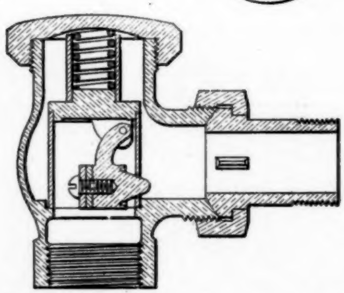


The drips are sealed from the return in the usual manner, either by a loop seal or check valve.

The construction of the automatic valves is shown in the small cuts, in which it will be seen that the discharge valves for the radiators are a special form of automatic impulse valve, in which

the seat is made of considerably smaller area than the pipe connections. It is also at such an angle as to prevent wedging or sticking, and it will pass the ordinary dirt of the system without trouble. A cone projects from the disk of the valve into the opening of the seat and a counterweight is applied in such a manner that they both act to render the opening of the valve very gradual





for increasing differences in pressure. On the disk of the valve there is placed an impact surface which is designed to materially increase the opening when water is passing.

The removal of air from the return pipe is accomplished by means of the automatic relief valve, which is acted upon by the varying pressures created in the return pipe by reason of the presence of air or steam.

With the boiler filled to the proper water line and a fire started

the action of the apparatus is as follows: Steam is generated and enters the main, and the friction of its flow causes a pressure in the boiler which communicates itself to the under side of the diaphragm of the relief valve and closes the air outlet. This outlet remains closed until the pressure passes into the radiators, opens the automatic discharge valves and compresses the air in the return pipes. The relief valve then opens and passes the air as fast as the combined delivery of the discharge valves. The flow continues until the air passes out of the radiators and return pipes, and the pressure in the returns is sufficiently reduced by the condensation of the steam to allow the relief valve to close.

As the automatic relief valve operates in the same manner as an air valve it is adjusted in the same manner; the weight is pushed out upon the lever until the valve is opened and blows steam freely; when the return pipe is free of air and thoroughly heated the weight is pushed back until the flow ceases.

A lower pressure than that in the steam main is then continually maintained in the return main, the difference depending upon how much difference in pressure is required to pass the amount of steam that is condensed in the return pipes through the automatic valves upon the radiators.

If a radiator that has been shut off is turned on, the air passes into the return through the automatic valve at the same rate, or under the same difference in pressure, as the steam through the other automatic valves. The pressure in the return then rises and opens the relief valve for the expulsion of the air.

By reducing the weight upon the relief valve a little more than is necessary to close it and just leaving it heavy enough to open when the system is cooled down, it is very easy to keep the return pipes partially filled with air at all times. This air flows along with the steam and collects at the relief valve ready to be discharged whenever some is introduced from a radiator.

Any radiator may be partially heated by graduating the opening of the inlet valve upon it. Steam then enters and passes across the top of the radiator and water collects in the bottom until the air in the radiator is compressed, both by being reduced to smaller volume and by heating, to equal the pressure in the return; the water then passes out and the radiator is not further heated until the volume of steam admitted is sufficient to cause the drainage valve to pass air as well as water.

The weight upon the automatic drainage valve is made of minimum amount, or just sufficient to close it, and it is thus opened by a very light pressure or head of water.

The system is run as a vacuum system by first raising enough pressure to expel all the air, and then allowing the fire to cool until the desired amount of vacuum is obtained; the entry of air from the discharge of the relief valve being prevented by a check valve or other similar means.

DISCUSSION.

Mr. James Mackay: Where is the air discharged, in the ash-pit?

Mr. Donnelly: It may be discharged in the ash-pit, into the chimney flue or simply into the air.

Mr. James Mackay: If the water should find its way through the automatic relief valve into the main or return this controlling valve prevents water finding its way into the discharge.

Mr. Donnelly: Water can never rise into this because it runs into the boiler.

Mr. Gormly: It seems to me there would be a tendency for radiators to expand across the top and there might be a tendency to rupture the radiator at the bottom sections.

Mr. Donnelly: There are a number of systems and methods of heating which use hot-water radiators with steam connection at the top in this manner, and they have been used for a number of years. Probably some of those who have been using these radiators can tell us about it.

Mr. Gormly: In a case I had, in every instance where we put radiators in, inside of three years we had to take them out. It cost us about twice what the job was worth in each instance. I have been shy of that system since, and I believe the trouble may have been caused in that instance by the manner of connecting the radiators together.

Mr. Barron: I want Mr. Donnelly to tell us how his system is superior to systems illustrated in our Proceedings some years back, furnished by our French member, M. Debesson, of Paris; published in the Proceedings and discussed at various meetings. They were gravity systems. A number of American vacuum

systems are quite similar. All I want to know is the superiority of Mr. Donnelly's system as compared to that.

Mr. Donnelly: I think the question of superiority to this system is rather a commercial one, perhaps. The French system, as I understand it, is a vapor system and not a vacuum system, though it might be made one. The principal superiority of this to that, I should say, is that these radiators are very close to the maximum temperature—they equal the temperature of the steam in the boiler probably closer than the French system. Another advantage of this is that, if necessary or desirable, they can be run at any pressure. You can graduate the heat of any individual radiator while running under that pressure. One other advantage I think is, there is no special attention or method necessary to condense the steam delivered into the return pipes, the return pipes themselves not being specially used as a condenser. The diaphragm has the pressure upon one side within a quarter or half pound of the pressure on the other, and it is impossible to rupture the diaphragm. Having water on both sides, it doesn't become vulcanized and get hard as with water on one side and air on the other.

Mr. R. C. Carpenter: Where and how long has this been in use?

Mr. Donnelly: It followed other work I did upon another system, and has been in use about two years.

President Kent: Are there no automatic air valves in the radiators?

Mr. Donnelly: No, not at all.

President Kent: Don't the radiators fill up with condensation?

Mr. Donnelly: No; perfectly clear.

Mr. James Mackay: In graduating the radiation one statement says this can be readily done by graduating the opening of the supply valve. How is it done, by hand?

Mr. Donnelly: Yes.

Mr. James Mackay: Will this controlling valve that controls the air outlet close automatically, or does it depend on some pressure to close it?

Mr. Donnelly: On excess pressure in the steam main over that in the return main. If there is fifteen inches of vacuum in the steam main there would be fifteen and a half inches of vacuum in the return main.

President Kent: What prevents the water coming out of that air outlet?

Mr. Donnelly: It is far enough above the water line, so the water doesn't rise that high.

Mr. Barron: I think this paper shows we are evolving an almost perfect system of house heating. This system of Mr. Donnelly's with thermostatic control of the inlet valve would be almost perfect, being regulated so the occupant of each room could control his own radiator. The same applies to Professor Carpenter's system. We have overcome the defects of the French systems and others and have evolved a more or less perfect low-pressure heating system.

Mr. Barwick: Is a drip always necessary on the steam main?

Mr. Donnelly: If the steam main pitches back towards the boiler there is no drip necessary at the end of the steam main. When the steam main pitches down from the boiler a drip is necessary, and it is dropped down sufficient to seal the steam from entering the return.

President Kent: I understand the water rises in these radiators.

Mr. Donnelly: The water collects at the bottom, as I said. Suppose you had a moderate pressure, two or three pounds, the radiator is full of air, and a slight compression due to steam entering would open the drainage valve; the higher pressure you are carrying on the boiler the higher that compression of air would have to be carried before the discharge valve would open. A small quantity of water would collect in the bottom before that pressure would rise high enough.

President Kent: Suppose you shut off the steam on the radiator and that steam gets condensed, would that make a vacuum on the radiator?

Mr. Donnelly: Yes; the same care must be taken to make the return valve tight as in any two-pipe system. A leaky valve on the return is open to the same objection in this system as in the two-pipe gravity system, the water will collect. In the ordinary two-pipe system the water would not run out when the pressure dropped, but this automatic valve would open when the pressure dropped so the water could get out of the radiator.

The ¾-inch impulse valve I have shown here is large enough for all ordinary radiators. I have it on radiators or coils as large

as four or five hundred square feet with a $\frac{1}{4}$-inch seat. On a coil twelve hundred square feet I have used the same valve with a $\frac{3}{8}$-inch seat, the difference in pressure between the steam and return is that necessary to raise this weight in both cases. Unless the amount of radiation on the return is very excessive you need a comparatively small amount of steam in the return. These valves will pass steam in passing water or water in passing steam, whichever way you figure it.

Mr. Barwick: Is it necessary to use a relief valve for each riser?

Mr. Donnelly: If the risers are some distance apart, one having very large radiators and the other one small radiators, the difference between the two groups being considerable, each one should have separate control, but if the two risers were a moderate distance apart they could be connected together because the conditions in the two would be approximately the same.

CLVIII.

REPORT OF COMMITTEE ON COLLECTION OF DATA ON FURNACE HEATING.

At the annual meeting of January, 1905, the undersigned Committee was appointed to collect data on furnace heating. This Committee formulated a series of questions concerning furnace heating, with a plan of a residence to be heated, to facilitate the answering of the questions, copies of which were sent to each member of the Society. The fact that the past year has been one of such unusual activity in business is probably the reason that only one member found the time to prepare answers to the long list of questions. The trade press also printed the questions proposed by the Committee, and *The Metal Worker, Plumber and Steam Fitter* received only one reply, which is also presented herewith.

The Committee desires to present the set of questions and the two replies as a preliminary report to be used as a subject of discussion at this meeting, and it urges those members of the Society who are interested in the subject of furnace heating to contribute to the Committee during the coming year such data as they conveniently can furnish concerning any experimental results they may have secured or any matter whatever which they think will be a contribution to the discussion of the subject. Formulæ for use in calculation, together with reasons for using the constants in such formulæ, are especially desired.

The Committee asks to be continued and hopes to be able next year to present a more ,complete report.

Respectfully,

WM. KENT,
FRANK K. CHEW,
C. E. OLDACRE.

WARM AIR FURNACE HEATING.

1. What rule or formula would you use for obtaining the following: Heat lost by conduction and radiation from buildings through walls, windows, roofs, etc.? Heat lost by warm air escaping from the building?

2. The sum of these two losses is the total heat that must be supplied to the circulating air by the furnace. What quantity of air should be passed over the furnace in order to absorb this amount of heat? Have you a formula or rule for obtaining this?

3. Suppose the outdoor temperature is zero and the temperature of the hall or other part of the house from which air may be drawn into the cold air box is 60 degrees, what proportion of the air would you draw from the outside and what from inside in an ordinary dwelling house of 8 to 12 rooms?

4. How would you calculate what would be the maximum temperature of the air passing over the furnace? Do you consider this the most advisable temperature of the air at the outlet?

5. What rule or formula have you for proportioning the extent of the heating surface or the furnace to the maximum quantity of heat to be given to the air by the furnace?

6. What rule have you for diameter of fire pot, depth of fire pot, diameter of grate and for maximum rate of combustion per square foot of grate surface per hour?

7. What rule have you for determining area of pipe admitting cold air from outdoors? If pipe is used for inside circulation, what then?

8. What rule have you for area of heater pipes leading from furnace to first, second and third floors?

9. What rule have you for the sum of the areas of all the air outlets of the furnace?

10. What rule have you for the area of the registers?

11. What preference have you to the location of registers in different rooms?

12. What is your rule for area of foul air outlet from the house?

13. What method have you for insuring entrance and circulation of warm air in every room, particularly the side of the house exposed to the strongest cold winds?

14. What is your opinion of warm air heating where a positive means of circulation is used, including both inlet and exit pipes for every room? Do you know of any examples and where?

15. Design a system of heating by warm air for the accompanying floor plans under the following conditions: The house fronts to the north and the prevailing cold winds are northwest; the lowest outside temperature is 20 degrees below zero. The library has a grate for a wood or coal fire. The house is well built; the windows on the north and the northwest rooms are double. All windows and doors are provided with weather strips and are as air tight as they can be. Show the location of furnace and location and sizes of all pipes for fresh air, warm air, air circulation out of rooms and foul air exits, size and location of registers. The kitchen and laundry and the two unfinished rooms on the third floor are not supposed to be heated. Give a rule, a reason or formula for the adoption of every detail.

16. Do you live in a furnace heated house? If so, can you furnish any experimental data obtained from the heating system, such as the following:

In extreme cold weather what is the temperature of air outdoors, temperature indoors in different rooms. Size of building. Cubic contents of rooms. Exposure. Number of pounds of coal burned in 12 hours daytime and 12 hours night. Number of pounds of coal burned per season. Temperature of air entering furnace. Temperature of warm air at several registers. Velocity of air in flues and through the registers. Area of inlet and cold air from outdoors. Area of inlet from hall or other parts of the house.

17. What are the principal faults that you have found in warm air heating installations when they have been incorrectly installed?

18. Please suggest any other questions or any modification of the above questions which would tend to bring out useful data in regard to warm air heating.

ANSWERS TO THE QUESTIONS BY WM. G. SNOW.

In reply to the set of questions propounded by the Committee appointed at the last meeting of the Society to collect data on furnace heating, I give answer below to a number of them:

1. Ordinary walls, either 13-inch brick or good frame construction, transmit roughly one-quarter as much heat as the same area of glass. Base the loss of heat through glass with 70 degrees difference in temperature at 85 heat units per square foot per hour, to be increased 25 per cent. for north or west exposure and 15 per cent. for east. The loss of heat through a ceiling separating a room from an unheated attic space may be taken approximately as one-twentieth the loss of heat through the same area of glass with 70 degrees inside and zero out. In other words, the equivalent glass surface of the ceiling, as above stated, is equal to the area of same divided by 20. Each cubic foot of air escaping at 70 degrees in zero carries practically $1\frac{1}{4}$ heat units.

2. Let the total heat supplied to the circulating air per hour equal H. Assume that the air is heated from 0 to 140 degrees. One heat unit will heat (in round numbers) 50 cubic feet 1 degree, or will heat 1 cubic foot 50 degrees, or 0.357 cubic foot 140 degrees. Hence H will heat $H \times 0.357$ cubic foot from 0 to 140 degrees. For example, a furnace with a 26-inch pot giving off 139,000 heat units per hour would heat about 50,000 cubic feet per hour from 0 to 140 degrees.

3. This would depend a great deal upon the use of the rooms at the time. For example, at night, when fresh air in sleeping rooms could be taken in through windows slightly raised, all the air could be returned from the house. In case an unusual

number of occupants were present and a good many gas lights were burning, all the cold air should be taken from the outside. Between these two limits any desired portions to meet existing conditions could be adopted.

4. Take, for example, a furnace with a 24-inch grate and, say, 3 square feet of free area for the passage of air; we might safely assume that the velocity would be 275 feet per minute, corresponding to 49,500 cubic feet per hour. A 24-inch grate burning coal at the rate of five pounds per square foot an hour and assuming the utilization of 8,000 heat units per pound of coal would give 125,200 heat units per hour transmitted to the air. Since one heat unit will raise 50 cubic feet of air 1 degree, 125,200 heat units would raise 49,500 cubic feet 127 degrees. Anywhere from 120 to 140 degrees would be considered a fair temperature for furnace heat.

5. I would say that 1 square foot of heating surface should not be relied on to give off more than 2,500 heat units per hour. Take the case cited in No. 4. Such a furnace would have in round numbers 50 square feet of heating surface and would give off 2,500 heat units per square foot per hour. It would be better of course to rate the furnace at not over 2,000 heat units per square foot an hour. As a rule furnaces have from 15 to 20 square feet of effective heating surface per square foot of grate. Many furnaces have a great deal more than this, but much of the surface is relatively inefficient.

6. The writer does not understand what is intended as to rule for diameter of fire pot. As to the depth it should be not less than 12 inches, and the dome above it should be high enough to provide for carrying the pot heaping full of coal in cold weather. I find the maximum rate of combustion advisable to maintain in the coldest weather to be not greater than 5 pounds per square foot per hour. With a cast-iron pot this rate is likely to make red hot surface.

7. I would advise making the cold air box not less than 75 per cent. of the combined area of the hot air pipes, and I consider a larger area of cold air boxes to be better in view of the greater ease in keeping the house at a moderate temperature in mild weather by supplying a surplus of air through the registers beyond what would be required in the winter for heating the house. If inside circulation is provided I would consider

that merely supplemental to the regular cold air supply and would control it by a separate damper or have a swinging damper arranged to automatically cut down the cold air supply when the return air is being used.

8. The theory on which the size of the pipes would be based would require too much space to state fully in connection with these questions. The Committee is referred to pages 37, 38, 39 of the treatise on "Furnace Heating," by Wm. G. Snow.

9. The sum of the areas of all the air outlets of the furnace should be not less than 180 square inches to 1 square foot of grate surface.

10. The area of registers naturally follows the determination of the pipe sizes. They should have a net area from 10 to 25 per cent. in excess of the area of the pipe with which they are connected.

11. I believe in short pipes and believe it better to locate the registers near the inner partitions, not too far from the furnace, in order that the pipes shall have a sharp pitch and not exceed, say, 16 feet in length, as a maximum. The hot air discharged through the registers first goes to the ceiling and then gradually descends around the outside walls and windows, being chilled and falling toward the floor by gravity.

12. In case foul air outlets are provided, I would base their area on about a 15-minute air change in the room and a velocity of, say, 250 feet per minute.

13. The furnace should be so located that the pipes will be shortest that lead to the rooms exposed to the coldest winds. Make sure the cold air box slide is sufficiently open to furnish air to fill all the pipes.

14. I have used the positive system of circulation to heat small rooms remote from the furnace, placing a hood over the centre of the furnace, connecting the supply pipe with same and bringing the return from the room to the casing of the furnace near the floor. The hood mentioned is placed inside the regular furnace top and insures the hottest air reaching the pipe connected with it. I would not recommend this system for an entire house, as it is human nature for people to save coal at the expense of other things that are really more important, and one of the chief advantages in the furnace heating system properly installed is that the house cannot be heated without supplying it with fresh air.

15. The heights of the several stories are not stated, but assuming the first to be 9 feet, the second 8½ feet and the third 8 feet, I would proceed by computing the outside exposure, and to do this quickly would simply take the exposed walls of the first and second floors, assuming the nonheated portion to about offset the rooms on the third floor that are to be warmed. The total exposure would be about 2,700 square feet, which, according to the table on page 23 of "Furnace Heating," would require a furnace with a 28-inch pot.

I would compute the pipe sizes according to the table on page 38 of "Furnace Heating," and recommend locating the furnace nearly opposite the foot of the stairs to the cellar and under the northwest corner of the dining-room. If the house is to be heated to 70 degrees when the outside temperature is 20 degrees below zero, in case the air is taken from the outside, a furnace of about 46 per cent. greater capacity would be required than to heat the house in zero weather. (See page 51, "Furnace Heating.") It is hardly likely that in such severe weather it would be desired to burn sufficient coal to heat the house with outside air. I would therefore recommend a furnace having a 30-inch pot for the service mentioned.

16. I have lived in furnace-heated houses and give the following experimental data:

With an outside temperature of plus 5 degrees and cold air box wide open temperatures at first floor registers were 116, 114 and 146 degrees; velocity, 418 to 465 feet.

On the second floor register temperatures were 100 to 127 degrees and velocities 252 to 510 feet, the pipes being 6 to 8 inches in size, some of them of considerable length.

With an outside temperature of 24 degrees temperatures at first floor registers 104 and 106 degrees, velocities 306 to 334 feet; on the second floor 95 degrees temperature and 468 feet velocity in a 6-inch pipe.

With an outside temperature of 34 degrees velocity at first-floor register, 280 feet; second-floor, 286 feet.

In a house having a floor plan 29 x 35 feet the first and second floors heated in a run of 32 days with an average outside temperature of 27½ degrees and furnace having an average fire pot of practically 3 square feet, 2 pounds of coal per square foot an hour was burned on each square foot of grate, average, for the

entire 32 days of 24 hours each. The house was perfectly comfortable during this time and the furnace was coaled twice a day. During this run there was one cold day when the thermometer went to minus 5 degrees. During these 24 hours 300 pounds of coal were burned at a rate of about 4 35-100 pounds per square foot of grate per hour.

During a 20-day test in a similar house with a furnace having a 22-inch fire pot, with an area of 2.64 square feet, average outside temperature 26.3 degrees, the average rate of combustion was 1.84 pounds per square foot an hour. During one cold day when the temperature went to 7 degrees below zero and varied from that to 8 degrees above, 258 pounds of coal were burned, an average of 4.07 pounds per square foot an hour.

The house mentioned had about 1,700 square feet of exposed wall and glass, the latter being about one-sixth the total exposure. This house required 10 to 11 tons per season to heat it. The first floor was 8½ feet in the clear and the second floor 8 feet. During the cold day run, with an outside temperature of minus 8 degrees, temperature taken at first-floor registers varied from 119 to 164 degrees and on the second floor from 92 to 133 degrees.

The average of several tests made on the quantity of air entering a furnace with a 24-inch fire pot, the cold air box being about 80 per cent. the area of the pipes, showed about 900 cubic feet a minute supply. Tests made on furnaces having about a 24-inch fire pot showed in a run of seven days, with outside temperature of 24 degrees, 860 pounds of coal burned. The ashes weighed 90 pounds. Another run of a week, with 23 degrees outside temperature, showed 822 pounds burned, the ashes weighing 91 pounds.

17. Cold air box too small. Flues too shallow. Too little air space in furnace. Insufficient pitch to cellar pipes

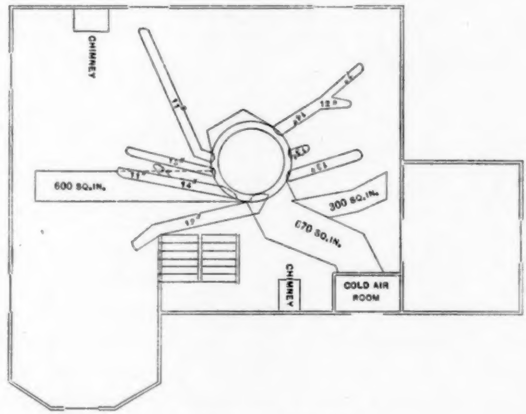
18. I think the Committee has gone into this subject pretty exhaustively and has no suggestions for further questions.

I wish the Committee success in getting the results of this examination paper in a shape that will be useful to the members of the Society.

ANSWERS TO QUESTIONS BY J. P. BIRD.

(Presented in the *Metal Worker, Plumber and Steam Fitter,* December 16, 1905.)

It will doubtless be recalled that in the *Metal Worker, Plumber and Steam Fitter* of May 6, 1905, there was printed a list of questions designed to bring out some valuable information on the size, pro-tems. This list was compiled by a committee of the American Society of Heating and Ventilating Engineers

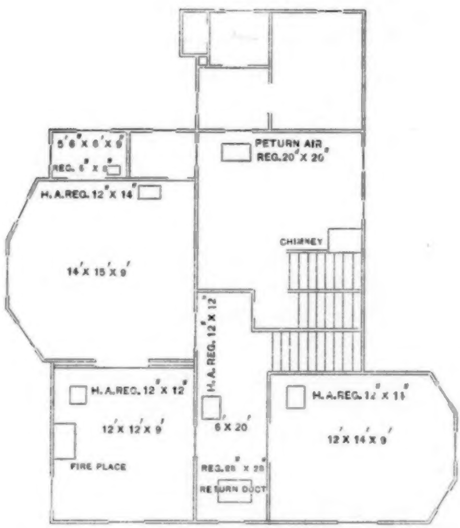


PLAN OF THE CELLAR.

appointed for the purpose and composed of Prof. William Kent, dean of the L. C. Smith School of Applied Science, Syracuse University, Syracuse, N. Y.; C. E. Oldacre of Philadelphia, and Frank K. Chew of this journal. The questions were printed in these columns with the plan drawings of a dwelling that accompanied them, in order that our readers could add to the praiseworthy investigation of the subject for the benefit of the furnace system of heating at large. A short time ago John P. Bird, 35 Centre Street, Putnam, Conn., favored us with a detailed set of answers to the questions mentioned, together with plan drawings and tail sketches showing the way he would install a furnace

heating system in the residence in question. He located the position of the furnace, air pipes and registers and gave the sizes which he considers should be used. Taking up the questions *seriatim*, Mr. Bird's opinions are as follows:

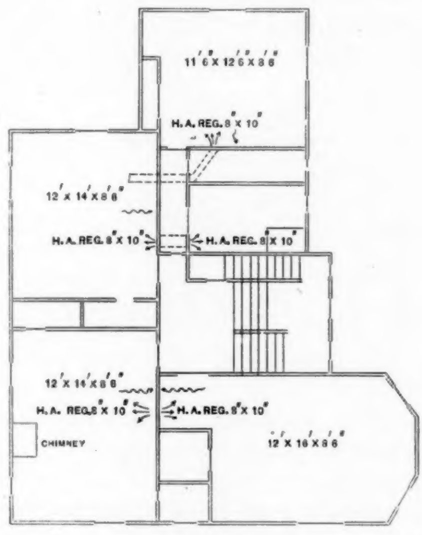
In reply to the question as to what rule or formula one would use for obtaining the amount of heat lost by conduction and radiation from buildings through walls, windows, roofs, etc., he states that he multiplies the calculated amount of the equivalent



PLAN OF FIRST FLOOR.

glass surface by 85, which gives the loss of heat per hour by transmission through the exposed walls, with the difference of 70 degrees in temperature between the conditions inside and outside of the house. To determine the loss by the warm air escaping from the building he adds to this amount $1\frac{1}{4}$ heat units for every cubic foot of air lost at 70 degrees through ventilation. The factor $1\frac{1}{4}$ is based on the fact that one heat unit will heat one cubic foot of air through 55 degrees, so that for every cubic foot of air lost at 70 degrees, and which has therefore had to be heated through 70 degrees, there will be 70-55th heat units lost per cubic foot, or approximately $1\frac{1}{4}$ heat units.

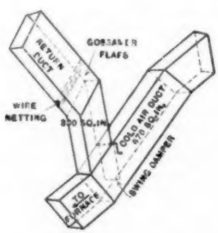
The second question stated that the sum of the losses by transmission through the walls and those by the escape of the air gave the total heat that must be supplied to the circulating air by the furnace, and asked what quantity of air should be passed over the furnace in order to absorb this amount of heat. Mr. Bird's rule is to divide the heat lost by transmission by 1.1, when the quotient will give the volume of warm air required per hour, which amount when divided by 60 gives the volume of warm air required per minute. This figure is based on air issuing into



PLAN OF SECOND FLOOR.

the rooms at 130 degrees and escaping at 70 degrees, its drop in temperature before it passes from the building giving up the heat that the walls will transmit. How he obtains this figure may be readily seen. The figure usually taken to connect heat units with the warming of air is that one heat unit will raise one cubic foot of air through 55 degrees or, vice versa, that in abstracting one heat unit from air one cubic foot will be cooled 55 degrees. Now with air entering at 130 and escaping at 70, that is being cooled 60 degrees, each cubic foot of air will give up more than one heat unit or 60-55ths heat unit, equal to 1.1. As the calculated loss by transmission through the walls gives

us the number of heat units supplied in an hour by the cooling of the air, and as one cubic foot gives up 1.1 heat units, the number of cubic feet will evidently be the quotient of the transmission loss divided by 1.1. If it is desired to use a similar formula for determining the amount of air on the basis of the total heat loss, it must be remembered that the air is raised from the outside temperature to the temperature at which the air is admitted into the rooms. For zero weather and 130 degrees at the registers this means that each cubic foot of air is raised through 130 degrees and that the total amount of air required will be found by dividing the total heat loss by $130 \div 55 = 2.47$. For a temperature of minus 10 outdoors the range of temperature

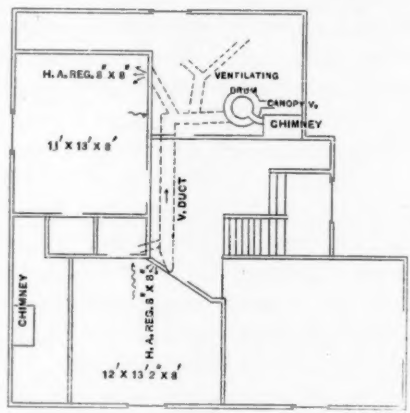


DUCT ARRANGEMENT FOR ROTATING AIR.

through which the air must be warmed is 140, and the dividing figure is consequently $140 \div 55 = 2.55$.

As to what proportion of air in a system which provides for a recirculation of the air within the house through the furnace should be drawn from the outside and what proportion from the inside in an ordinary dwelling house of 8 to 12 rooms, he says that he has never given any thought to or practiced the plan, but thinks that a system could be installed with a considerable saving of fuel. Taking an eight-room house occupied by six persons, there is probably no more than three persons in the house during the 10 hours of the day, when the air could be recirculated with no ill effect. He would provide a duct from the outside of three-fourths the size of the combined area of all the hot air pipes and a duct from the inside of the full capacity of the combined hot air pipes, this one to be connected into the cold air duct. He would provide a wind damper and gossamer flaps to stop back drafts.

His calculations for what is the maximum temperature of the air passing over a furnace are as follows: The amount of heat that 1 cubic foot of air will take up per degree rise in temperature is equal to $0.2377 \times 0.0864 = 0.0205$ heat unit. This is, of course, the product of the weight of 1 cubic foot of air, 0.0864 pound, by the specific heat of air 0.2377. He assumes that the house will require 84,000 cubic feet of air per hour, which is apparently based on four changes per hour, and selects a furnace having a 32-inch grate, or 5.58 square feet of grate surface. Taking a rate of combustion of 5 pounds of coal per



PLAN OF THE THIRD FLOOR.

square foot of the grate per hour, and assuming that 1 pound of coal supplies 8,000 heat units to the air he shows that this amount of coal will give off $40,000 \times 5.58 \times 5 = 223,200$ heat units per hour. This is the total amount of heat that can be supplied by the furnace at the stated rate of combustion. To heat the hourly supply, 84,000 cubic feet of air, $84,000 \times 0.0205 = 1,722$ heat units are necessary for every degree rise, so that the 223,200 heat units supplied from the coal will heat the given amount of air about 130 degrees ($223,200 \div 1,722 = 129.6$). It will be seen that in determining this temperature Mr. Bird has assumed the amount of air passing through the building, and also the rate of combustion for zero weather. He considers 130 the most advisable temperature of the air at the outlet, at least one not exceeding 140 degrees.

In regard to the heating surface of a furnace he prefers 12 square feet of heating surface to 1 square foot of grate surface, assuming 5 pounds of coal burned per square foot of the grate per hour. He says he has no formula for proportioning the extent of the heating surface.

To determine the area of the grate in the furnace his rule is as follows: "One pound of anthracite will emit 13,000 heat units, but I think 60 per cent. is as much as can be utilized, in round figures, say 8,000. Assuming 1 square foot of grate will consume 5 pounds of coal per hour, the combustion will give us 40,000 heat units per square foot of the grate. Dividing the total loss of heat for the house per hour by 40,000 will give us the area of the grate required. As most of our furnaces have tapering fire pots, I find that the average area will be that of the grate."

His rule for the area of the heater pipes leading from the furnace to the first, second and third floors is as follows: "Glass surface plus one-quarter the wall surface plus one-twentieth ceiling or floor area, when the attic or cellar is not heated, with 10 per cent. added for exposed places, gives the area of the equivalent glass surface. The equivalent glass surface multiplied by 85 gives the number of the heat units lost per hour. This result divided by 1.1 gives the volume of air per hour, and this result divided by 60 gives, of course, the volume of air required per minute. If the volume is divided by the velocity in feet per minute, the quotient, which will be in square feet, when reduced to square inches will give the size of the pipe required. I base the velocities at 280, 400 and 500 feet per minute for the first, second and third floors." The following example is worked out by Mr. Bird: "Assume a room 12 x 14 x 9 feet in size, with 39 square feet of glass surface and with two sides exposed toward the northwest. $12 \times 9 + 14 \times 9 = 234$; $234 - 39 = 195$; $195 \div 4 = 48\frac{3}{4}$ or 49; $49 + 39 = 88$ (equivalent glass surface in square feet). Ten per cent. added for severe exposure gives 97 square feet E.G.S. $97 \times 85 = 8{,}245$ (heat units lost per hour); $8{,}245 \div 1.1 \div 60 = 124\ 5\text{-}6$ or 125 (volume of air required per minute). $125 \div 280 = 0.446$ or 0.45 (square feet, which is equivalent to 64 square inches). This is greater than a 9-inch pipe, so I use a 10-inch pipe."

The area of registers he makes 25 per cent. in excess of the

hot-air pipe supplying the register. He prefers to have the registers in or near the inside walls, unless there is a fire-place in the room, and then he prefers them to one side of the fire-place. His reason for doing this is that he finds the air takes an upward course across the ceiling, so that if the register is not placed as suggested the floor will be cold.

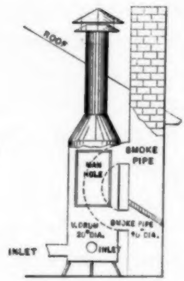
For the area of the foul air outlet from the house he has no hard and fast rule, but only uses his own judgment as to what the room will be used for. To insure the entrance and circulation of warm air in every room he provides an ample supply of air to the furnace, and in the rooms on the side of the house exposed to the strong cold winds he uses a larger pipe than would otherwise be necessary. He has had no experience in warm air heating where a direct means of circulation is employed, including both inlet and exit pipes from every room.

DESIGN OF SYSTEM FOR ACCOMPANYING PLANS.

He replied as follows to the fifteenth question, which was: Design a system of heating by warm air for the accompanying floor plans under the following conditions: The house fronts to the north and the prevailing cold winds are northwest; the lowest outside temperature is 20 degrees below zero. The library has a grate for a wood or coal fire; the house is well built; the windows in the north and northwest rooms are double; all windows and doors are provided with weather strips and are as air tight as they can be. Show the location of furnace and location and sizes of all pipes for fresh air, warm air, air circulation out of rooms and foul air exits, size and location of registers. The kitchen and laundry and the two unfinished rooms on the third floor are not supposed to be heated. Give a rule, a reason or formula for the adoption of every detail.

"As near as I can make out by the plans we have 3,400 square feet of wall surface, 476 square feet of glass surface or 1,326 square feet of equivalent glass surface. The number of heat units lost per hour by transmission with the 90 degrees difference in temperature inside and outside is $1,326 \times 104 = 137,704$. Basing the number of occupants at ten persons and supplying 1,800 cubic feet of air per hour per occupant will require 18,000

cubic feet of air. This amount represents in the loss of heat by ventilation $18{,}000 \times 1.25 = 22{,}500$ heat units. This makes a total of 160,204 heat units to be supplied by the heater per hour. Assuming one pound of coal will supply 8,000 heat units per hour to the air and a rate of combustion of five pounds of coal per square foot of the grate per hour, we shall require 4 square feet of grate surface or a heater with a 30-inch grate." (We feel that it is only right to say that while Mr. Bird may find



SCHEME TO SECURE POSITIVE VENTILATION.

this method of calculating for the total heat losses and therefore for the size of the furnace satisfactory in his practice, we differ on the point of determining the amount of air. It will probably be recalled that on December 2 under an editorial entitled "Some Considerations on Furnace Heating Design" it was explained that in residential work the amount of air that is admitted should be great enough to supply the heat losses by transmission without introducing the air at too high a temperature, the resultant volume of air being great enough so that satisfactory ventilation is assured for the occupants of the building. We feel sure that in the system as calculated by Mr. Bird there would be a greater flow of air through the building than assumed when the temperature outside is at its minimum of 20 degrees below zero.)

"You will find the size and location of the air pipes marked on the plans and also the size of the registers. As no dimensions of the studding were given in the plans I assume a 6-inch clearance. For the second floor I would use oval pipes 5 x 15 inches in size and for the third floor 5 x 10 inches. You will also see that I heat two rooms with one pipe. Many engineers object to

this plan, but I have installed several heaters on this arrangement and found them to give good satisfaction, with, I think, a saving of fuel. You will please note that in all cases but the hall and third floor bedroom I heat the two rooms on one floor, for I have found when you heat one on the first and one on the second the upper one has a tendency to rob the lower one.

"You will see that I take my cold air supply from the west side, and also that I have a cold air chamber, which I think insures an even supply of air. The plans will give you the size. I have also provided return ducts. The method of connecting to cold air ducts is shown in an attached sketch as well as the dampers and gossamer flaps employed.

CHIMNEY TEMPERATURES AND VENTILATION.

"For ventilation the plans provide for a fire-place in the library, which I presume will use wood as a fuel. I have made tests on chimneys with wood fires in stoves and found an average difference between the temperature inside and outside the chimney of 40 degrees, but I think you will find that with an open fire-place the difference in temperature will be greatly reduced—say, 50 per cent.—which will make a difference of 20 degrees. The chimney will be 30 feet high, 78 square inches in area and with a 20 degrees difference in temperature will remove about 144 cubic feet of air per minute. In my opinion there will be ample ventilation on the first floor by the fire-place without the kitchen, which I would ventilate with a canopy or register behind the stove. As you will see that we have to remove 300 cubic feet of air per minute I should install a drum in the attic, as shown in one of the accompanying engravings. I have installed one such apparatus to ventilate a ten-room house, with canopy over the range connected with it, and it gives entire satisfaction. A more positive method of ventilating is that which I advocated in a previous article to your columns." (This method was illustrated in the *Letter Box* for May 13th in reply to a correspondent who wanted a satisfactory method of heating and ventilating. It shows a 12-inch chimney flue passing up through a 24 x 32 inch brick flue, with the vent pipe entering into the shaft, where the heat of the smoke flue could be utilized for accelerating the up draft of the air.)

Among principal faults found in warm air installations Mr. Bird mentions the lack of air supply and poor workmanship in erecting, the latter including the pushing of pipes too far into boots and leaving large holes where the pipes are connected together. He says that the apparatus is often entirely too small owing to the general inclination of customers to accept the lowest bidder, and that there is also a lack of common intelligence in taking care of and running the furnace.

DISCUSSION.

Mr. Chew: We have an answer from R. L. Spellerberg, Dubuque, Iowa, which shows a system of heating not in general use as far as I can learn. It brings out two points. The basis of it is the use of a large cellar main. If he is going to heat four rooms instead of running four separate pipes, he runs one large main equivalent to the required area of each one of the different registers. He says in reference to it that the cost is but little cheaper than the individual pipe system, but that it has other advantages. For instance, if you are forced to locate the furnace on account of the stairs somewhat different than you would otherwise or for an individual pipe system, you get a better flow of air to the several points than if you had to run a separate pipe to all of them. There is another thing in connection with this that he brings out. In the last few years the register manufacturers are entitled to be complimented upon the departure from the old register which when used in connection with partition flues in particular cut off a good portion of their effective area, and he uses in connection with his system a new type of side wall register and a new type of partition pipe or riser. Instead of the 4 x 16 flue you can get as much as a 9 x 12, 15 or 18-inch flue, whatever the studding will allow you to get. This type of register is attracting a good deal of attention from furnace men at the present time. Those are two points brought out by this man's paper. He uses the large cellar main system quite frequently—almost exclusively in his practice. I find that it is also done by one of our former members, J. G. Sorgen, San Francisco, and by one or two other men in the East. It has not become general furnace practice.

This committee asks to be continued, and desires to thank very heartily those men who have answered the questions prepared. We think a good deal of useful information has been obtained. We know there are more furnace men in this Society who could give information that would be useful, and we would be glad to have them do it. We refused to submit a report at the summer meeting, in Chicago, because we thought we would get more information, and I hope we will get more information later on. Men in Chicago pledged themselves to give us information. It took ten years to get a ventilation law in New York, and it may take ten years for this committee to make a final report.

Mr. Bolton: In connection with the points brought out by Mr. Snow and others, there seems to be one feature to which more prominence should be given, and that is the matter of the proportions of air intakes. I consider in a general way that there is much to be learned on that subject. I live in a furnace-heated house, and have been learning something in relation to furnace heating. I have effected one change in connection with the furnace of my own house which has been a distinct improvement, by lowering the furnace into a pit. Another practical difficulty in city houses is the irregular temperature maintained in the neighboring dwellings. You may have on one side a neighbor who maintains a low temperature in his house, while on the other side the house may be kept very warm, making a considerable difference of temperature on the two sides of the intermediate building. It is common in many city houses to have all registers on one side, and under the foregoing circumstances the temperatures on the different sides may disarrange results.

As to the methods of firing there is a divergence of opinion. I have been trying to see what would be the best form of fire to maintain. There is one reference in Mr. Snow's paper that leads me to suppose the accepted method is to carry a high fire in the fire pot. This may be right when the furnace is at full capacity, but I find that in moderate weather a low fire is sufficient, and in cold weather it may be heaped up with good results.

Mr. Lyman: Mr. Snow speaks about the diameter of the fire-box. It seems to me if the diameter of the fire-pot at the

upper line is given, as customary by manufacturers, we should have data relative to the diameter of the grate and the various local parts.

Mr. Snow: In a brick-lined furnace, of course, the pot is cylindrical, and in that case the grate area is taken as the average cross-section area of the fire-pot, whether at the top or at the bottom.

Mr. Berry: With regard to question seven and cold-air supply, my experience indicates that much depends on the control of a large supply by suitable dampers, also upon the method used in admitting the air supply to the heating surfaces.

Where large heaters are used, it is advisable to construct deflectors or trench plates and walls in the cold-air chamber at the base of the heater to divide and direct the air to all of the heating surfaces.

With a strong wind blowing into the cold-air duct, or installations equipped with a fan or blower, special devices should be used that are adjustable.

I have secured good results with air ducts divided into flues about 12 inches square, these flues being turned upward directly under and around the heating surfaces.

In some of the older installations placed in Philadelphia forty years ago the cold air supply was worked out along the above lines with remarkably good results.

President Kent: I think the committee would be glad to welcome any correspondence, even if members don't answer all of the eighteen questions, but answer only one and bring out some important facts.

(President Kent here drew a plan of furnace on the board.)

That represents a furnace. This condition exists in some houses where there is no preparation made for the air to get out, but yet the house gets heated. These rooms have double windows and are air-tight, but the rooms get heated notwithstanding it is against the laws of nature to say air can get in when there is no place to get out. The fact is, it must find some place to get out. Of course the circulation is imperfect. I had a case years ago where it was impossible to heat an upper room in the front of the house with the wind in a certain direction. One day I took a kerosene lamp and warmed the bot-

tom of the vertical pipe, and after it was warmed it started the circulation, and as soon as the pipe was warmed the air went up. In some houses they have a fireplace in one or two of the rooms, which are carefully plugged up with paper or other things to prevent the air getting out from the house. So heating the house by hot air has scarcely yet got to a thorough scientific system, by first providing an air inlet, and secondly by providing a circulating device, and thirdly by providing an outlet. I think furnace heating, when it becomes thoroughly perfected, will have all these three things—a fresh-air inlet, a circulating device, and a foul-air outlet.

Mr. Payne: There is one method overlooked in the fresh-air supply which is becoming prominent, and that is getting fresh air from the cellar.

Mr. Bolton: The fireplaces form a natural vent for each room. And, further, what I think should be done is to carry the air into certain areas. Of course the hot air nearly all ascends up the stairways and practically to the upper floors, to the rooms on the upper floors, which not supplied with heat at all are notwithstanding pretty thoroughly heated.

President Kent: There is another point. In a house in which the circulating pipe is a long distance from the inlet pipe, when working properly there is a strong downward current. I once placed a sheet of paper on the register in the hall and it was pulled down strongly, and then it was shot up by air from the outside which reversed the current and threw the cold air into the hall instead of the hot air. These circulating flues sometimes work backward. The cold-air inlet was partly shut, probably only a three-inch opening, but the strong wind outside was sufficient to put enough pressure in there to reverse the current in that circulating pipe.

Mr. Chew: I wish Mr. Lyman would repeat the conversation he had with me this morning in reference to large cellar mains for the interest of the gentlemen here.

Mr. Lyman: In answer to Mr. Chew's question, we were referring to an article in the *Metal Worker*, and my criticism of the one trunk circuit where one, two, three or four registers were taken from one pipe was that the average cellar we find up through the State does not have a height of more than 6½ or 7 feet. It is rare that you find a cellar higher than that.

The castings of the average warm-air heater having a 24-inch fire-pot are about 48 inches high, and when you come to put on a top of 10 inches more you get pretty close to the joists. Then if you use a single trunk line pipe of 15 inches or even 14 inches diameter, and undertake to carry that to three or four registers, you will have no elevation to your pipe, and this is a serious objection even when a large pipe is required for a single register. Instead of running one 15-inch pipe I would run two 10-inch pipes side by side in one register, simply because I could get better elevation of the lines. And may I add to what the President said, in regard to the method of circulating air back to the heater, suggesting a method which has been adopted in a few instances, I think, of taking return flues from registers in each room, and then have an outside cold-air supply taken through an 8-inch or 10-inch flue (perhaps made of terra cotta), and carried under and to the centre of the furnace. This gives a supply of fresh air sufficient for the average family, and a positive circulation, with no danger of short-circuiting the fresh cold air back through the inside pipes.

Mr. Chew: The good old custom of the times when I first mixed up in the furnace business was to use the mason work flue that had been abandoned for a smoke flue, oftentimes 9 x 13 and seldom less than 8 x 8. I am firmly of the opinion that the old, rough, abandoned smoke flue 8 x 8 effected better heating than the 4 x 16 wall stack having practically the same area, yet that is the only kind of flue the furnace men can find in houses now being built. I don't believe as much air will flow through it.

We have present to-day a new member who comes into this Society as the result of reading a paper on furnace heating at the convention of the National Association of Sheet Metal Workers last August. That Association wrote to this Society for the privilege of printing and reading one of our papers on furnace heating before that body, and thought very highly of it. An invitation was extended by me, on the convention floor, for any member of that Association to be present at this meeting who felt inclined to come, and I sent a special invitation to some of them, and some are here. One man in particular is here, and that man has had the courage to carry war into Egypt by advocating a plan of heating which was in use a

good many years ago, before it went out of use for mercenary reasons, to save cost to the builder, for the builder didn't care whether his final customer burned a good deal of coal or not. All he wanted was to build the house with the least trouble to him, and that is the reason the partition flue has supplanted the good old construction of ample area. I speak of Mr. Sabin, of Philadelphia, a new member. In Philadelphia he has, single-handed, gone to the builders and personally guaranteed if they will allow him to put in furnaces as they should be put in the customers will be better satisfied and success will attend the heating system he recommends. Mr. Sabin has put in some houses in Philadelphia—and is likely to expand his business if a good thing is appreciated as it should be—round risers instead of the 4 x 12 or 4 x 14 wall stack. In my opinion there is no flue that will approach a round flue. It carries a volume of air with little friction. I want to know whether I am wrong in advocating the round flue and condemning the partition flue, as I have done for twenty odd years. I want to know whether I am right or not in saying the partition flue makes a man burn more coal, and whether to accomplish the warming of a room he does not have to have a higher temperature than with a flue of more natural shape.

Prof. R. C. Carpenter: There seems to be no objection to the position Mr. Chew takes. One reason we don't get velocity through the chimney is because of friction which is proportional to the extent of surface in contact with the moving air. Take a flue 8 x 8, and we have an area of 64 square inches, and a perimeter of 32 inches; with a flue 4 x 16, we have an area of 64 square inches and a perimeter of 40 inches, for which case there is more rubbing surface and more friction. The effect of this excess friction on the flow is very serious, and so serious, I think, that engineers should always take it into account when designing flues where it is essential to obtain good results. The case of furnace heating is similar to hydraulic problems relating to the flow of fluids. I think a solution will be worked out on similar lines which will give scientific coefficients for the design of air pipes and flues.

Mr. Chew: It goes to show that the builder can, if he desires, arrange the building so there is no objection to this character of heating system in the majority of instances. Maybe

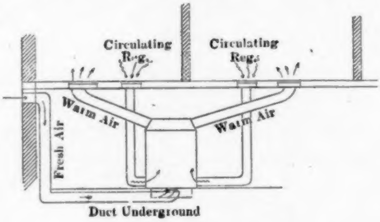
a chimney breast here or a closet or some other contrivance there, which don't make the extension into the room unsightly to the eye. I built some houses in 1888 that have been occupied when other similar houses in the locality were not, because they could be heated with about as little coal as some people burn in a front room stove. It is a little bit of a furnace in the cellar which you can almost take under your arm. It discharges hot air in a 10-in. round riser from the top of the furnace. The riser is constructed with a division on the first floor, part of the air going to one room and part to another. Immediately above the top of the register is a damper, and an 8-inch round pipe goes to the two rooms on the second floor. These houses have been occupied ever since they were built, even when other houses in the same neighborhood were not occupied, for the reason the people could live there without extravagant expenditure for fuel. The furnaces have never been repaired since that time, and the whole thing, registers, sheet metal work and all was done for less than $50 for each house, and there was a good profit in it. Fifty dollars per complete heating system for four rooms.

Mr. Lyman: One point in relation to this, the heat risers to the room should be larger than the circulating pipe—in about the relative proportion of 10-inch flue pipe and 8-inch pipe for return. The size of air duct that comes from out-of-doors would be regulated by the size of the house. Plenty of air for ventilating purposes is secured, and at the same time positive circulation in every room is assured.

Mr. Sabin: For the last few years warm-air furnaces have been in bad repute, because the majority of such furnaces have been installed in such a bad manner that it is impossible to get good results from them even if an abundant quantity of fuel was used. In some cases it has been the furnace contractor's fault in using very poor judgment in installing his work. But in a great majority of cases, which have come under the writer's notice, the fault has been with the architect or builder who has failed to provide proper space for the vertical heat flue; in other words, has compelled the heating contractor to place vertical stacks within such narrow partitions that it was impossible to put in a heat stack of the proper size or area to give even fair results.

I believe that a good warm-air furnace system properly installed will give as good results for the average size dwelling house as any other system that can be installed with an abundant supply of fresh air and at a less cost than any other system that will give equal results.

In reference to the round riser system we have made a special effort in the last year to induce Philadelphia builders to use the round risers. What induced us to do it more especially than anything else was the reason in a majority of cases the houses as built in Philadelphia have a chimney breast in the centre of the parlor which extends out about 12 inches. It is built so as to give ample space for a round riser or hot-air pipe to the second or third floor rooms. We never had difficulty to heat the parlor or second floor room above the parlor where we could use the round pipe. That is what induced us



more especially to suggest the round riser system. Of course we also have tried to get people to put in floor registers for return cold air. There was one particular house with a round riser system of hot-air flues complete which Mr. Chew described in full detail, with plans, in *The Metal Worker,* November 4, 1905, and I have data here in connection with that house which I think will be interesting. There is no theory about it—it is actual fact, taken by the gentleman living in the house. It gives the temperature of the rooms, the amount of fuel consumed, etc. The house is in West Philadelphia, at the northeast corner of Fifty-first and Irving Streets, facing west, with a southern exposure. It contains about 20,000 cubic feet, and exposes 821 square feet of equivalent glass surface. The furnace has a 23-inch grate, or about 3 square feet of grate surface. The area of the hot-air pipes is 429 square inches. The air supply is two 12-inch pipes, or 226 square inches, from the dining room and hall, and a 12 x 30-inch duct controlled by a damper from the

outside. In two different winters but 8 tons of coal per winter have been ample fuel. This I attribute largely to the use of round risers instead of thin wide partition flues to the register on the upper floors. It is 1 ton of coal for the season for 2,400 cubic feet of space, or 1 ton for 100 square feet of equivalent glass surface. The circulation of the air in the house, of course, also has an important effect on the fuel consumption. There are no floor registers for hot air. The round risers are all 9 inches in diameter, except to the parlor, which is 9 inches, and to the bathroom, which is 7 inches. The table herewith may be of interest for the data it contains:

TABLE OF DIMENSIONS AND PROPORTIONS.

	Contents.	Wall.	Glass.	E. G. S.	Diameter of Pipe.	Area of Pipe.	One Square Inch H. A. P. Area to Contents.	One Square Inch H. A. P. Area to E. G. S.
	Cu. Ft.	*Sq. Ft.*	*Sq. Ft.*	*Sq. Ft.*	*Inches.*	*Sq. In.*	*Cu. Ft.*	*Sq. Ft.*
Halls, all floors	4,357	228	24	74	9	63	69	1.2
Parlor	1,425	100	29	40	9	63	22.6	.63
Dining-room	1,938	123	40	61	9	63	30	1
Sitting-room	2,081	176	45	78	8	50	41	1.5
Bathroom	549	87	12	31	7	40	26	1.5
Dining-room chamber	1,804	139	25	53	8	50	69	2.8
Kitchen chamber	1,665	250	38	91				
Front chamber	1,912	102	25	50	8	50	38	1
Bath	484	85	12	30	....	....	....	....
Middle chamber	1,402	102	25	50	8	50	61	2.8
Back chamber	1,657	246	38	90				
Party wall	....	....	....	173	....	....	....	....
Totals and ratios	19,274	1,638	304	821	....	429	45	1.9

The house is about 18 x 60, and has twelve rooms. The gentleman who lives in it has made some memorandums as follows:

Fire started Oct. 15, 1905, to dry house.

Moved in house Oct. 26, 1905. North house adjoining not finished. Doors and windows not in. Cold party-wall to heat.

Nov. 12, 1905: Outside air ducts not yet open; house very comfortable; air seems good without fresh air from the outside; sleeping rooms have windows open at night; all doors are open through the house from room to room and into hall; house comfortable mornings; temperature outside 26 degrees; inside 60 degrees at 6.30 A.M.

November 16: To-day looks like good, cold, clear weather;

outside temperature at 6 A.M. 22 degrees; temperature inside at 6 A.M. 63 degrees.

December 8: Adjoining house on north side not yet completed nor any fire in it; have burned to date about 2½ tons of coal since October 15, 1905.

January 9, 1906: Temperature outside 14 degrees 5 A.M.; temperature inside dining room 60 degrees 5 A.M.; temperature inside sitting room 64 degrees 5 A.M.; one of the sitting-room registers open to admit heat to third floor front room; coldest day so far this winter.

January 10, 1906: Outside temperature, 5 A.M., 18 degrees; temperature inside, 5 A.M., dining room, 66 degrees; temperature inside, 5 A.M., sitting room, 65 degrees; cold-air duct from outside closed overnight and fire banked; have used to date about 3½ tons of coal; can heat the house all over with a moderate fire and can run the temperature to 85 degrees from 70 degrees in about twenty minutes after draft is put on. Cylinder red hot first time this winter.

Jan. 11, 1906: Temperature outside at 6.30 A.M., 20 degrees; dining room at 6.30 A.M., 62 degrees; sitting room at 6.30 A.M., 69 degrees; dining room was more cold to-day than yesterday because fire in kitchen range was out over night.

Jan. 12, 1906: Temperature outside at 5.30 A.M, 34 degrees; dining room at 5.30 A.M., 64 degrees; sitting room at 5.30 A.M., 68 degrees.

January 13, 1906: Temperature outside at 5.30 A.M., 29 degrees; dining room at 5.30 A.M., 71 degrees; sitting room at 5.30 A.M., 78 degrees; outside air was heavy; rained all day; cleared at night; wind from the northwest; did not check fire enough; house was too warm; burned about 90 lbs. of coal to-day in 24 hours; cold stormy day; when temperature outside is from 14 to 16 degrees above zero will burn about 115 lbs. of coal a day of 24 hours. All doors open except back third story.

January 14: Sunday; home all day; 8 A.M. temperature outside, 31 degrees; temperature inside dining room, 68 degrees; temperature inside sitting room, 72 degrees; 9 A.M., sleeting.

January 15, 1906: Four months to-day since fire was started in furnace; have used four tons of coal; at this rate cannot possibly use over eight tons of coal from October 15 to April

15; temperature outside, 31 degrees; temperature of dining room, 69 degrees; temperature of sitting room, 73 degrees; adjoining house on the north not occupied, and no fire in it.

Mr. B. C. Davis: Very often there are sliding doors and plenty of room for the round pipe. We have put in a great many furnaces in our section of the country, Kansas City using round pipe. We have many installations out there where we returned the air from all the first floor rooms back to the furnace. We are great believers in that country in bringing all the air under the bottom of the ash pit. Also, in this cold air connection we put in a swinging damper which closes off the supply of air to the furnace the harder the wind blows. The wind blows against the damper, which swings against a baffle wall and closes the opening, reducing the capacity for fresh air. The damper is hinged at the top and we have found it successful.

Mr. Chew: Mr. Bolton spoke of the desirability of pitch in furnace pipes, and I understood him to almost think it was more necessary than the area of the air supply equaling that of the hot air outlets. When there is a lack of air supply, air will come down some pipe to eke out any scarcity of air through natural sources of supply, and it is rather a dangerous thing to cut the area for the supply of air down below two-thirds of the area of the combined hot air outlets.

Another thing brought out at the Chicago meeting was the value of the circulation of air in the house and the danger of over-ventilation. Where there is one servant girl in the house and two or three children, and there are 25,000 or 35,000 cubic feet of space, they don't need all the air from the outside, and there is a great deal of fuel charged up against the furnace due to the over-ventilation. The first time I heard that phrase "over-ventilation" was in connection with Mr. Thompson's paper, backed up by Prof. Carpenter, in Chicago, and I think it is a good one, and should be brought out every once in a while. There is not the need for all the air for furnace-heating systems to be taken from out-of-doors all the time.

Mr. B. C. Davis: Mr. Chew's remarks have suggested another scheme we have used. Provide a large ventilating flue, of sufficient capacity to carry ventilation from all rooms up to

the atmosphere, the base of flue to be connected to the air supply to the furnace. In this flue we place a damper above the last opening from the rooms, and if we want to return the air we close the damper. If we want to ventilate the building we open the damper. There should be a damper where the stack is connected to the furnace supply pipe, which should be connected to the damper in the stack above mentioned, that will admit fresh outside air to the furnace when the building is ventilated. This is a cheap scheme and something we can put in without much expense.

Mr. Berry: Mr. Snow in his paper refers to the air temperature at the registers. I would suggest a general or standard method of taking air temperatures at registers, viz.: the centre of the register opening and in the centre of the air flue. In normal practice readings I have taken under the above conditions with standard tested thermometers show a temperature of 165 degrees to 175 degrees. These temperatures are required to keep the apartments to 70 degrees in weather from 12 to 20 degrees above zero, using liberal sized ducts in residence practice.

Mr. R. C. Carpenter: At one time we made a test in a large building, viz: The Veterinary College at Cornell University (see Proceedings, Vol. V.), and compared the actual heat wasted with the actual fuel consumed. If the question is asked, how the theoretical results check up with practical methods, I should say that they check up very nicely. We found out as a result of that test that the heat loss from a building agrees closely with the formula $Q=(T-T^1)(\frac{1}{4}W + G)$, in which

T = inside temperature,
T^1 = outside temperature,
W = area of exposed wall in sq. ft.
G = area of glass in sq. ft.

That is the only opportunity I ever had on a large scale to measure the relation between the actual heat supplied and that discharged.

President Kent: There are six different losses of heat we have to consider.

1. Heat conducted through the walls.
2. Heat required for ventilation.
3. Heating air in excess of that required for ventilation.
4. Heat lost due to imperfect combustion.
5. Heat required to furnish chimney draft.
6. Heat for heating air discharged into the chimney in excess of that required for draft.

A complete test of a heating and ventilating system would involve the consideration of all these losses.

Mr. R. C. Carpenter: I measured the amount of heat carried off. The dimensions of the building were given. I checked up by calculation the coefficient for heat loss given in my work on heating and ventilation. The results checked up closely, the trial lasting over seven weeks.

President Kent: We have guarantees to heat buildings to seventy degrees, but I haven't heard of a guarantee to heat a building with a certain amount of fuel. When it comes to that we will have more difficulty than we have now. I have an impression this part of the heat loss (6) is rather a small one, especially when using anthracite coal. Heat lost due to imperfect combustion is greater if we shut off the draft partially than if we shut it off entirely. If we shut off the draft at night, after ten hours, we find considerable coal remaining in the furnace. As for the heat required to furnish chimney draft, we put on a good deal of draft to burn coal quite rapidly, but in the ordinary furnace heating and steam-boiler heating, with a small-sized bed of coals, there is not much excess air above that required for draft. So in general these conditions are fairly good in the ordinary furnace, but there are great losses due to excess ventilation, to imperfect walls, single windows, and things of that kind.

Mr. Chew: I have been talking with a gentleman who said he burned seventeen tons of coal one season, that he spent his vacation in remodeling his apparatus, and the next year burned eight tons of coal.

We can figure out the consumption from the exposed glass surface, but the consumption in the average home when Dinah, Gretchen and Bridget and the rest run the fire is quite a little different. Then when you come to bad installation, as the first installation must have been when seventeen tons of coal

were burned, it shows it is not always the theory that is wrong in estimating the amount of coal that should be burned, but something wrong in the installation.

Mr. Barron: I want to get a specific declaration from Mr. Chew. In changing this installation he refers to, was this changed from a furnace-heated house to a hot-water heated house?

Mr. Chew: No, sir; I do not know what was in it, in the first place; all I know is the fact. Mr. Davis can advise you.

Mr. B. C. Davis: The air was taken from the outside, and there was no inside circulation. The furnace was lowered eighteen inches, and the air supply increased to 75 per cent. of the capacity of the pipes. A return air connection was placed in the large rooms on the first floor and one round pipe from the second floor. It reduced the fuel bill about one-third.

CLIX.

REPRINT OF DR. BENJAMIN FRANKLIN'S ORIGINAL PAPER ON THE PENNSYLVANIAN FIREPLACE.

CONTRIBUTED BY MR. ALBERT A. CARY.

See page 36 of these Proceedings.

An Account of the new-invented Pensylvanian Fire-Places: wherein their Construction and Manner of Operation is particularly explained; their Advantages above every other Method of warming Rooms demonstrated; and all Objections that have been raised against the Use of them answered and obviated. With Directions for putting them up, and for using them to the best Advantage. And a Copper-Plate, in which the several parts of the Machine are exactly laid down, from a Scale of Equal Parts.

BY B. FRANKLIN.

(First printed at Philadelphia in 1745.)

IN these northern colonies the inhabitants keep fires to sit by generally seven months in the year; that is, from the beginning of October, to the end of April; and, in some winters, near eight months, by taking in part of September and May.

Wood, our common fuel, which within these hundred years might be had at every man's door, must now be fetched near one hundred miles to some towns, and makes a very considerable article in the expence of families.

As therefore so much of the comfort and conveniency of our lives, for so great a part of the year, depends on the article of *fire*; since fuel is become so expensive, and (as the country is more cleared and settled) will of course grow scarcer and dearer, any new proposal for saving the wood, and for lessening the charge, and augmenting the benefit of fire, by some particular method of making and managing it, may at least be thought worth consideration.

The new fire-places are a late invention to that purpose, of which this paper is intended to give a particular account.

That the reader may the better judge whether this method of managing fire has any advantage over those heretofore in use, it may be proper to consider both the old and new methods separately and particularly, and afterwards make the comparison.

In order to this, it is necessary to understand well, some few of the properties of air and fire, viz.

1. Air is rarefied by *heat*, and condensed by *cold*, *i. e.* the same quantity of air takes up more space when warm than when cold. This may be shown by several very easy experiments. Take any clear glass bottle (a Florence flask stript of the straw is best) place it before the fire, and as the air within is warmed and rarefied, part of it will be driven out of the bottle; turn it up, place its mouth in a vessel of water, and remove it from the fire; then, as the air within cools and contracts, you will see the water rise in the neck of the bottle, supplying the place of just so much air as was driven out. Hold a large hot coal near the side of the bottle, and as the air within feels the heat, it will again distend and force out the water.---Or, fill a bladder not quite full of air, tie the neck tight, and lay it before a fire as near as may be without scorching the bladder; as the air within heats, you will perceive it to swell and fill the bladder, till it becomes tight, as if full blown: remove it to a cool place, and you will see it fall gradually, till it becomes as lank as at first.

2. Air rarefied and distended by heat is * specifically lighter

* Body or matter of any sort, is said to be *specifically* heavier or lighter than other matter, when it has more or less substance or weight in the same dimensions.

lighter than it was before, and will rise in other air of greater density. As wood, oil, or any other matter specifically lighter than water, if placed at the bottom of a vessel of water, will rise till it comes to the top; so rarefied air will rise in common air, till it either comes to air of equal weight, or is by cold reduced to its former density.

A fire then being made in any chimney, the air over the fire is rarefied by the heat, becomes lighter, and therefore immediately rises in the funnel, and goes out, the other air in the room (flowing towards the chimney) supplies its place, is rarefied in its turn, and rises likewise; the place of the air thus carried out of the room, is supplied by fresh air coming in through doors and windows, or, if they be shut, through every crevice with violence, as may be seen by holding a candle to a key-hole: If the room be so tight as that all the crevices together will not supply so much air as is continually carried off, then, in a little time, the current up the funnel must flag, and the smoke being no longer driven up, must come into the room.

1. Fire (*i. e.* common fire) throws out light, heat, and smoke (or fume.) The two first move in right lines, and with great swiftness, the latter is but just separated from the fuel, and then moves only as it is carried by the stream of rarefied air: and without a continual accession and recession of air, to carry off the smoaky fumes, they would remain crouded about the fire, and stifle it.

2. Heat may be separated from the smoke as well as from the light, by means of a plate of iron, which will suffer heat to pass through it without the others.

3. Fire sends out its rays of heat as well as rays of light,

light, equally every way; but the greatest sensible heat is over the fire, where there is, besides the rays of heat shot upwards, a continual rising stream of hot air, heated by the rays shot round on every side.

These things being understood, we proceed to consider the fire-places heretofore in use, *viz.*

1. The large open fire-places used in the days of our fathers, and still generally in the country, and in kitchens.

2. The newer-fashioned fire-places, with low breasts, and narrow hearths.

3. Fire-places with hollow backs, hearths, and jams of iron (described by M. Gauger, in his tract entitled, *La Mechanique de Feu)* for warming the air as it comes into the room.

4. The Holland stoves, with iron doors opening into the room.

5. The German stoves, which have no opening in the room where they are used; but the fire is put in from some other room, or from without.

6. Iron pots, with open charcoal fires, placed in the middle of a room.

1. The first of these methods has generally the conveniency of two warm seats, one in each corner; but they are sometimes too hot to abide in, and, at other times, incommoded with the smoke; there is likewise good room for the cook to move, to hang on pots, &c. Their inconveniencies are, that they almost always smoke, if the door be not left open; that they require a large funnel, and a large funnel carries off a great quantity of air, which occasions what is called a strong draft to the chimney, without which strong draft the smoke would come out of some part or other of so large

large an opening, so that the door can seldom be shut; and the cold air so nips the backs and heels of those that sit before the fire, that they have no comfort till either screens or settles are provided (at a considerable expence) to keep it off, which both cumber the room, and darken the fire-side. A moderate quantity of wood on the fire, in so large a hearth, seems but little; and, in so strong and cold a draught, warms but little; so that people are continually laying on more. In short, it is next to impossible to warm a room with such a fire-place: and I suppose our ancestors never thought of warming rooms to sit in; all they purposed was, to have a place to make a fire in, by which they might warm themselves when cold.

2. Most of these old-fashioned chimneys in towns and cities, have been, of late years, reduced to the second sort mentioned, by building jambs within them, narrowing the hearth, and making a low arch or breast. It is strange, methinks, that though chimneys have been so long in use, their construction should be so little understood till lately, that no workman pretended to make one which should always carry off all smoke, but a chimney-cloth was looked upon as essential to a chimney. This improvement, however, by small openings and low breasts, has been made in our days; and success in the first experiments has brought it into general use in cities, so that almost all new chimneys are now made of that sort, and much fewer bricks will make a stack of chimneys now than formerly. An improvement, so lately made, may give us room to believe, that still farther improvements may be found to remedy the inconveniencies yet remaining. For these new chimneys, though they keep rooms generally free from

 smoke,

smoke, and, the opening being contracted, will allow the door to be shut, yet the funnel still requiring a considerable quantity of air, it rushes in at every crevice so strongly, as to make a continual whistling or howling; and it is very uncomfortable, as well as dangerous, to sit against any such crevice. Many colds are caught from this cause only, it being safer to sit in the open street, for then the pores do all close together, and the air does not strike so sharply against any particular part of the body.

The Spaniards have a proverbial saying,

> If the wind blows on you through a hole,
> Make your will, and take care of your soul.

Women particularly, from this cause, as they sit much in the house, get colds in the head, rheums and defluctions, which fall into their jaws and gums, and have destroyed early many a fine set of teeth in these northern colonies. Great and bright fires do also very much contribute to damage the eyes, dry and shrivel the skin, and bring on early the appearances of old age. In short, many of the diseases proceeding from colds, as fevers, pleurisies, &c. fatal to very great numbers of people, may be ascribed to strong drawing chimneys, whereby, in severe weather, a man is scorched before while he is froze behind.* In the mean time, very little

* As the writer is neither physician nor philosopher, the reader may expect he should justify these his opinions by the authority of some that are so. M. Clare, F. R. S. in his treatise of *The Motion of Fluids*, says, page 246, &c. "And here it may be remarked, that it is more prejudicial to health to sit near a window or door, in a room where there are many candles and a fire than in a room without; for the consumption of air thereby occasioned, will always be very considerable, and this must necessarily be replaced

tle is done by these chimneys towards warming the room; for the air round the fire-place, which is warmed by the direct rays from the fire, does not continue in

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replaced by cold air from without. Down the chimney can enter none, the stream of warm air always arising therein absolutely forbids it, the supply must therefore come in wherever other openings shall be found. If these happen to be small, *let those who sit near them beware*; the smaller the floodgate, the smarter will be the stream. Was a man, even in a sweat, to leap into a cold bath, or jump from his warm bed, in the intensest cold, even in a frost, provided he do not continue over-long therein, and be in health when he does this, we see by experience that he gets no harm. If he sits a little while against a window, into which a successive current of cold air comes, his pores are closed, and he gets a fever. In the first case, the shock the body endures, is general, uniform, and therefore less fierce; in the other, a single part, a neck, or ear perchance, is attacked, and that with the greater violence probably, as it is done by a successive stream of cold air. And the cannon of a battery, pointed against a single part of a bastion, will easier make a breach than were they directed to play singly upon the whole face, and will admit the enemy much sooner into the town."

That warm rooms, and keeping the body warm in winter, are means of preventing such diseases, take the opinion of that learned Italian physician Antonino Parcio, in the preface to his tract *de Militis Sanitate tuenda*, where, speaking of a particular wet and cold winter, remarkable at Venice for its sickliness, he says, "Popularis autem pleuritis quæ Venetiis sævit mensibus *Dec. Jan. Feb.* ex cæli, aërisque inclementia facta est, quod non habeant hypocausta [*stove-rooms*] & quod non soliciti sunt Itali omnes de auribus, temporibus, collo, totoque corpore defendendis ab injuriis aëris; et tegmina domorum Veneti disponant partum inclinata, ut nives diutius permaneant super tegmina. E contra, Germani, qui experiuntur cæli inclementiam, perdidicere sese defendere ab aëris injuria. Tecta construunt multum inclinata, ut decidant nives. Germani abundant lignis, domusque *hypocaustis*; foris autem incedunt pannis pellibus, gossipio, bene mehercule loricati atque muniti. In Bavaria interrogabam (curiositate motus videndi Germaniam) quot nam elapsis mensibus pleuritide vel peripneumonia fuissent absumti: dicebant vix unus aut alter illis temporibus pleuritide fuit correptus.

The great Dr. Boerhaave, whose authority alone might be sufficient, in his

in the room, but is continually crouded and gathered into the chimney by the current of cold air coming behind it, and so is presently carried off.

In both these sorts of fire-places, the greatest part of the heat from the fire is lost; for as fire naturally darts heat every way, the back, the two jambs, and the hearth, drink up almost all that is given them, very little being reflected from bodies so dark, porous, and unpolished; and the upright heat, which is by far the greatest, flies directly up the chimney. Thus five-sixths at least of the heat (and consequently of the fuel) is wasted, and contributes nothing towards warming the room.

3. To remedy this, the Sieur Gauger gives, in his book entitled, La Mechanique de Feu, published in 1709, seven different constructions of the third sort of chimneys mentioned above, in which there are hollow cavities made by iron plates in the back, jambs, and hearths, through which plates the heat passing warms the air in those cavities, which is continually coming into the room fresh and warm. The invention was very

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his *Aphorisms*, mentions, as one antecedent cause of pleurisies, "A cold air, driven violently through some narrow passage upon the body, over-heated by labour or fire."

The eastern physicians agree with the Europeans in this point; witness the Chinese treatise entitled, *Tschong seng*; i. e. *The Art of procuring Health and long Life*, as translated in Pere Du Halde's account of China, which has this passage. "As, of all the passions which ruffle us, anger does the most mischief, so of all the malignant affections of the air, a wind that comes through any narrow passage, which is cold and piercing, is most dangerous; and coming upon us unawares insinuates itself into the body, often causing grievous diseases. It should therefore be avoided, according to the advice of the ancient proverb, as carefully as the point of an arrow." These mischiefs are avoided by the use of the new-invented fire-places, as will be shown hereafter.

ingenious

ingenious, and had many conveniencies: the room was warmed in all parts, by the air flowing into it through the heated cavities: cold air was prevented rushing through the crevices, the funnel being sufficiently supplied by those cavities: much less fuel would serve, &c. But the first expence, which was very great, the intricacy of the design, and the difficulty of the execution, especially in old chimneys, discouraged the propagation of the invention; so that there are, I suppose, very few such chimneys now in use. [The upright heat, too, was almost all lost in these, as in the common chimneys.]

4. The Holland iron stove, which has a flue proceeding from the top, and a small iron door opening into the room, comes next to be considered. Its conveniencies are, that it makes a room all over warm; for the chimney being wholly closed, except the flue of the stove, very little air is required to supply that, and therefore not much rushes in at crevices, or at the door when it is opened. Little fuel serves, the heat being almost all saved; for it rays out almost equally from the four sides, the bottom and the top, into the room, and presently warms the air around it, which, being rarefied, rises to the ceiling, and its place is supplied by the lower air of the room, which flows gradually towards the stove, and is there warmed, and rises in its turn, so that there is a continual circulation till all the air in the room is warmed. The air, too, is gradually changed, by the stove-door's being in the room, through which part of it is continually passing, and that makes these stoves wholesomer, or at least pleasanter than the German stoves, next to be spoken of. But they have these inconveniencies. There is no sight of the fire, which is in

in itself a pleasant thing. One cannot conveniently make any other use of the fire but that of warming the room. When the room is warm, people, not seeing the fire, are apt to forget supplying it with fuel till it is almost out, then, growing cold, a great deal of wood is put in, which soon makes it too hot. The change of air is not carried on quite quick enough, so that if any smoke or ill smell happens in the room, it is a long time before it is discharged. For these reasons the Holland stove has not obtained much among the English (who love the sight of the fire) unless in some workshops, where people are obliged to sit near windows for the light, and in such places they have been found of good use.

5. The German stove is like a box, one side wanting. It is composed of five iron plates screwed together, and fixed so as that you may put the fuel into it from another room, or from the outside of the house. It is a kind of oven reversed, its mouth being without, and body within the room that is to be warmed by it. This invention certainly warms a room very speedily and thoroughly with little fuel: no quantity of cold air comes in at any crevice, because there is no discharge of air which it might supply, there being no passage into the stove from the room. These are its conveniencies. Its inconveniencies are, that people have not even so much sight or use of the fire as in the Holland stoves, and are, moreover, obliged to breathe the same unchanged air continually, mixed with the breath and perspiration from one another's bodies, which is very disagreeable to those who have not been accustomed to it.

6. Charcoal fires in pots are used chiefly in the shops

shops of handicraftsmen. They warm a room (that is kept close, and has no chimney to carry off the warmed air) very speedily and uniformly; but there being no draught to change the air, the sulphurous fumes from the coals [be they ever so well kindled before they are brought in, there will be some] mix with it, render it disagreeable, hurtful to some constitutions, and sometimes, when the door is long kept shut, produce fatal consequences.

To avoid the several inconveniencies, and at the same time retain all the advantages of other fire-places, was contrived the Pensylvanian fire-place, now to be described.

This machine consists of

A bottom-plate, (i) *(See the Plate annexed.)*

A back plate, (ii)

Two side plates, (iii iii)

Two middle plates, (iv iv) which, joined together, form a tight box, with winding passages in it for warming the air.

A front plate, (v)

A top plate (vi)

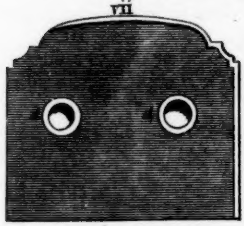
These are all cast of iron, with mouldings or ledges where the plates come together, to hold them fast, and retain the mortar used for pointing to make tight joints. When the plates are all in their places, a pair of slender rods, with screws, are sufficient to bind the whole very firmly together, as it appears in Fig. 2.

There are, moreover, two thin plates of wrought iron, viz. the shutter, (vii) and the register, (viii); besides the screw-rods O P, all which we shall explain in their order.

(i) The bottom plate, or hearth-piece, is round before, with

Fig. 3.

Plate & Joint of the proper size.



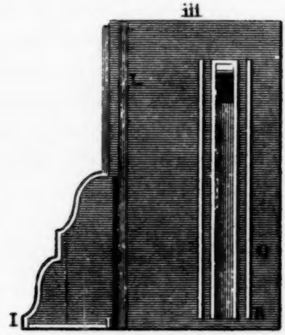
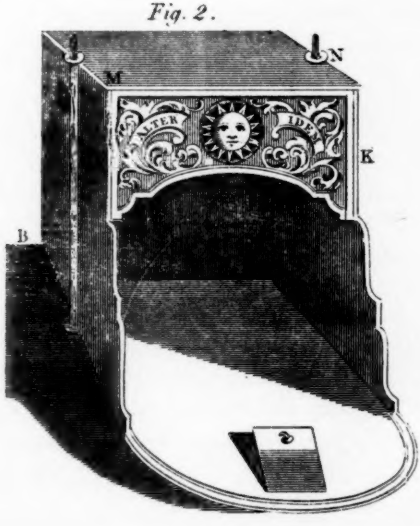


Fig. 2.

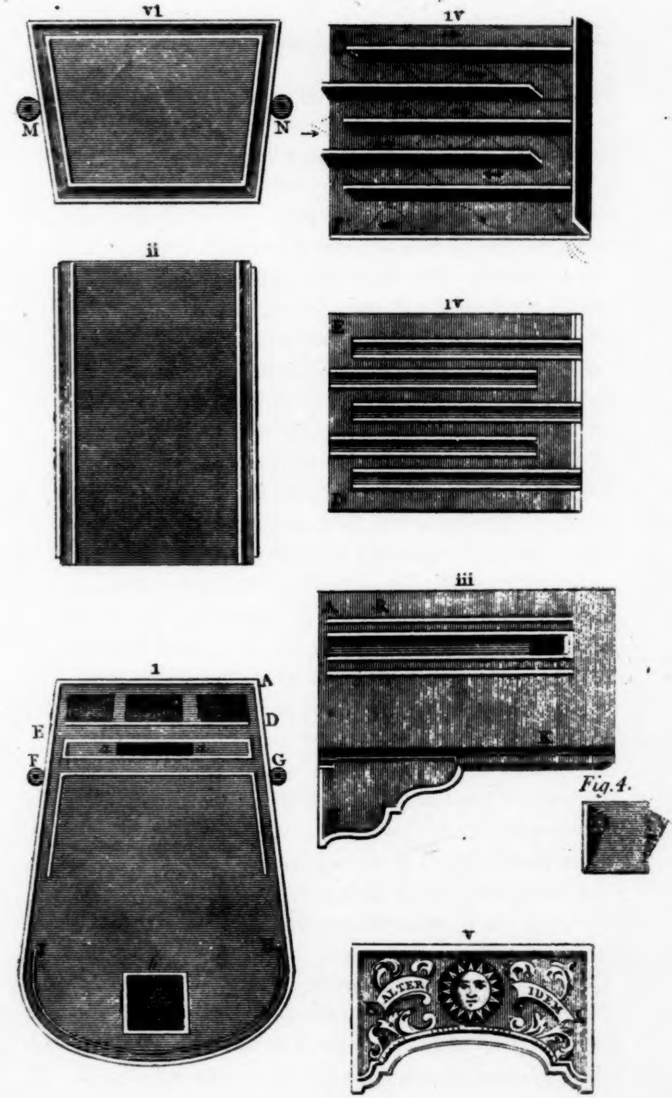


with a rising moulding, that serves as a fender to keep coals and ashes from coming to the floor, &c. It has two ears, F G, perforated to receive the screw-rods O P; a long air-hole, *a a*, through which the fresh outward air passes up into the air-box; and three smoke-holes B C, through which the smoke descends and passes away; all represented by dark squares. It has also double ledges to receive between them the bottom edges of the back plate, the two side-plates, and the two middle plates. These ledges are about an inch asunder, and about half an inch high; a profile of two of them, joined to a fragment of plate, appears in Fig. 3.

(ii) The back plate is without holes, having only a pair of ledges on each side, to receive the back edges of the two.

(iii iii) Side-plates: These have each a pair of ledges to receive the side-edges of the front-plate, and a little shoulder for it to rest on; also two pair of ledges to receive the side-edges of the two middle plates which form the air-box; and an oblong air-hole near the top, through which is discharged into the room the air warmed in the air-box. Each has also a wing or bracket, H and I, to keep in falling brands, coals, &c. and a small hole, Q and R, for the axis of the register to turn in.

(iv iv) The air-box is composed of the two middle plates, D E and F G. The first has five thin ledges or partitions cast on it, two inches deep, the edges of which are received in so many pair of ledges cast in the other. The tops of all the cavities formed by these thin deep ledges, are also covered by a ledge of the same form and depth, cast with them; so that when


vi
M
N
iv
ii
iv
E
D
iii
A
B
K
1
A
E
D
F
G
Fig. 4.
v
ALTER
IDEM
A Scale of Inches

the plates are put together, and the joints luted, there is no communication between the air-box and the smoke. In the winding passages of this box, fresh air is warmed as it passes into the room.

(v) The front plate is arched on the under side, and ornamented with foliages, &c. it has no ledges.

(vi) The top plate has a pair of ears, M N, answerable to those in the bottom plate, and perforated for the same purpose: it has also a pair of ledges running round the under side, to receive the top edges of the front, back, and side-plates. The air-box does not reach up to the top plate by two inches and a half.

(vii) The shutter is of thin wrought iron and light, of such a length and breadth as to close well the opening of the fire-place. It is used to blow up the fire, and to shut up and secure it at nights. It has two brass knobs for handles, *d d*, and commonly slides up and down in a groove, left, in putting up the fire-place, between the foremost ledge of the side-plates, and the face of the front plate; but some chuse to set it aside when it is not in use, and apply it on occasion.

(viii) The register is also of thin wrought iron. It is placed between the back plate and air-box, and can, by means of the key S, be turned on its axis so as to lie in any position between level and upright.

The screw-rods O P are of wrought iron, about a third of an inch thick, with a button at bottom, and a screw and nut at top, and may be ornamented with two small brasses screwed on above the nuts.

To put this machine to work,

1. A false back of four-inch (or, in shallow small chimneys, two inch) brick work is to be made in the chimney, four inches or more from the true back; from

from the top of this false back a closing is to be made over to the breast of the chimney, that no air may pass into the chimney, but what goes under the false back, and up behind it.

2. Some bricks of the hearth are to be taken up, to form a hollow under the bottom plate; across which hollow runs a thin tight partition, to keep apart the air entering the hollow and the smoke; and is therefore placed between the air-hole and smoke-holes.

3. A passage is made, communicating with the outward air, to introduce that air into the fore part of the hollow under the bottom plate, whence it may rise through the air-hole into the air-box.

4. A passage is made from the back part of the hollow, communicating with the flue behind the false back: through this passage the smoke is to pass.

The fire-place is to be erected upon these hollows, by putting all the plates in their places, and screwing them together.

Its operation may be conceived by observing the plate entitled, Profile of the Chimney and Fire-Place.

M The mantle-piece, or breast of the chimney.

C The funnel.

B The false back and closing.

E True back of the chimney.

T Top of the fire-place.

F The front of it.

A The place where the fire is made.

D The air-box.

K The hole in the side-plate, through which the warmed air is discharged out of the air-box into the room.

H The hollow filled with fresh air, entering at the

passage *I*, and ascending into the air-box through the air-hole in the bottom plate near

G The partition in the hollow to keep the air and smoke apart.

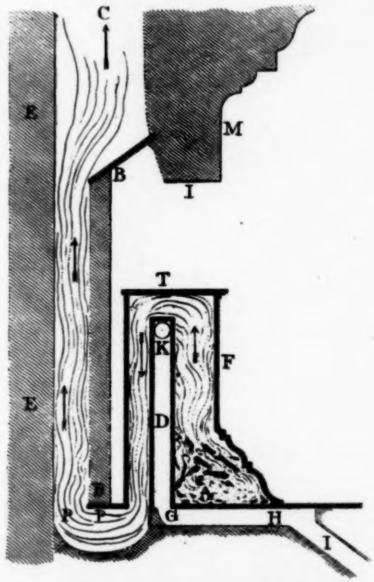
P The passage under the false back and part of the hearth for the smoke.

The arrows show the course of the smoke.

The fire being made at A, the flame and smoke will ascend and strike the top T, which will thereby receive a considerable heat. The smoke, finding no passage upwards, turns over the top of the air-box, and descends between it and the back plate to the holes in the bottom plate, heating, as it passes, both plates of the air-box, and the said back plate; the front plate, bottom and side plates are also all heated at the same time. The smoke proceeds in the passage that leads it under and behind the false back, and so rises into the chimney. The air of the room, warmed behind the back plate, and by the sides, front, and top plates, becoming specifically lighter than the other air in the room, is obliged to rise; but the closure over the fire-place hindering it from going up the chimney, it is forced out into the room, rises by the mantle-piece to the cieling, and spreads all over the top of the room, whence being crouded down gradually by the stream of newly-warmed air that follows and rises above it, the whole room becomes in a short time equally warmed.

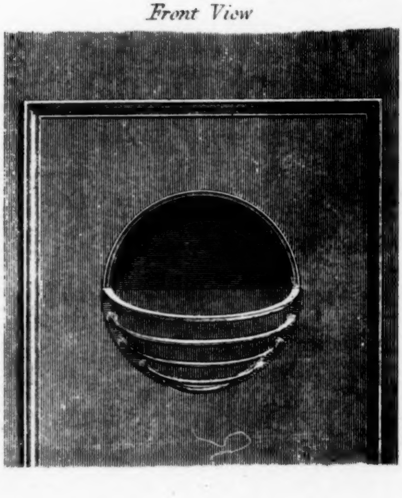
At the same time the air, warmed under the bottom plate, and in the air-box, rises and comes out of the holes in the side-plates, very swiftly, if the door of the room be shut, and joins its current with the stream before-mentioned, rising from the side, back, and top plates.

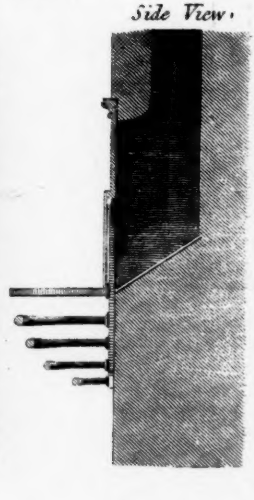
The



STAFFORDSHIRE FIRE-PLACE.

Front View *Side View.*





The air that enters the room through the air box is fresh, though warm; and, computing the swiftness of its motion with the areas of the holes, it is found that near ten barrels of fresh air are hourly introduced by the air-box; and by this means the air in the room is continually changed, and kept, at the same time, sweet and warm.

It is to be observed, that the entering air will not be warm at first lighting the fire, but heats gradually as the fire increases.

A square opening for a trap-door should be left in the closing of the chimney, for the sweeper to go up: the door may be made of slate or tin, and commonly kept closes hut, but so placed as that, turning up against the back of the chimney when open, it closes the vacancy behind the false back, and shoots the soot, that falls in sweeping, out upon the hearth. This trap-door is a very convenient thing.

In rooms where much smoking of tobacco is used, it is also convenient to have a small hole, about five or six inches square, cut near the ceiling through into the funnel: this hole must have a shutter, by which it may be closed or opened at pleasure. When open, there will be a strong draught of air through it into the chimney, which will presently carry off a cloud of smoke, and keep the room clear: if the room be too hot likewise, it will carry off as much of the warm air as you please, and then you may stop it entirely, or in part, as you think fit. By this means it is, that the tobacco smoke does not descend among the heads of the company near the fire, as it must do before it can get into common chimneys.

The

The Manner of using this Fire-Place.

Your cord-wood must be cut into three lengths; or else a short piece, fit for the fire-place, cut off, and the longer left for the kitchen or other fires. Dry hickery, or ash, or any woods that burn with a clear flame are rather to be chosen, because such are less apt to foul the smoke-passages with soot; and flame communicates with its light, as well as by contact, greater heat to the plates and room. But where more ordinary wood is used, half a dry faggot of brush-wood, burnt at the first making the fire in the morning, is very advantageous, as it immediately, by its sudden blaze, heats the plates, and warms the room (which with bad wood slowly kindling would not be done so soon) and at the same time by the length of its flame, turning in the passages, consumes and cleanses away the soot that such bad smoaky wood had produced therein the preceding day, and so keeps them always free and clean. When you have laid a little back log, and placed your billets on small dogs, as in common chimneys, and put some fire to them, then slide down your shutter as low as the dogs, and the opening being by that means contracted, the air rushes in briskly, and presently blows up the flames. When the fire is sufficiently kindled, slide it up again.* In some of these fire-places there is a little

* The shutter is slid up and down in this manner, only in those fire-places which are so made as that the distance between the top of the arched opening, and the bottom plate, is the same as the distance between it and the top plate. Where the arch is higher, as it is in the draught annexed (which is agreeable to the last improvements) the shutter is set by, and applied occasionally, because if it were made deep enough to close the whole opening when slid down, it would hide part of it when up.

six-inch square trap-door of thin wrought iron or brass, covering a hole of like dimensions near the fore-part of the bottom plate, which being oy a ring lifted up towards the fire, about an inch, where it will be retained by two springing sides fixed to it perpendicularly (*See the Plate, Fig.* 4.) the air rushes in from the hollow under the bottom plate, and blows the fire. Where this is used, the shutter serves only to close the fire at nights. The more forward you can make your fire on the hearth-plate, not to be incommoded by the smoke, the sooner and more will the room be warmed. At night, when you go to bed, cover the coals or brands with ashes as usual; then take away the dogs, and slide down the shutter close to the bottom-plate, sweeping a little ashes against it, that no air may pass under it; then turn the register, so as very near to stop the flue behind. If no smoke then comes out at crevices into the room, it is right: if any smoke is perceived to come out, move the register, so as to give a little draught, and it will go the right way. Thus the room will be kept warm all night; for the chimney being almost entirely stopt, very little cold air, if any, will enter the room at any crevice. When you come to re-kindle the fire in the morning, turn open the register before you lift up the slider, otherwise, if there be any smoke in the fire-place, it will come out into the room. By the same use of the shutter and register, a blazing fire may be presently stifled, as well as secured, when you have occasion to leave it for any time; and at your return you will find the brands warm, and ready for a speedy re-kindling. The shutter alone will not stifle a fire, for it cannot well be made to fit so exactly but that air will enter, and that in a violent stream, so as to blow up and

keep

keep alive the flames, and consume the wood, if the draught be not checked by turning the register to shut the flue behind. The register has also two other uses. If you observe the draught of air into your fire-place to be stronger than is necessary (as in extreme cold weather it often is) so that the wood is consumed faster than usual; in that case, a quarter, half, or two-thirds turn of the register, will check the violence of the draught, and let your fire burn with the moderation you desire: and at the same time both the fire-place and the room will be the warmer, because less cold air will enter and pass through them. And if the chimney should happen to take fire (which indeed there is very little danger of, if the preceding direction be observed in making fires, and it be well swept once a year; for, much less wood being burnt, less soot is proportionably made; and the fuel being soon blown into flame by the shutter, or the trap-door bellows, there is consequently less smoke from the fuel to make soot; then, though the funnel should be foul, yet the sparks have such a crooked up and down round about way to go, that they are out before they get at it). I say, if ever it should be on fire, a turn of the register shuts all close, and prevents any air going into the chimney, and so the fire may easily be stifled and mastered.

The Advantages of this Fire-Place.

Its advantages above the common fire-places are,

1. That your whole room is equally warmed, so that people need not croud so close round the fire, but may sit near the window, and have the benefit of the light for reading, writing, needle-work, &c. They may sit with comfort in any part of the room, which is a very

considerable advantage in a large family, where there must often be two fires kept, because all cannot conveniently come at one.

2. If you sit near the fire, you have not that cold draught of uncomfortable air nipping your back and heels, as when before common fires, by which many catch cold, being scorched before, and, as it were, froze behind.

3. If you sit against a crevice, there is not that sharp draught of cold air playing on you, as in rooms where there are fires in the common way; by which many catch cold, whence proceed coughs*, catarrhs tooth-achs, fevers, pleurisies, and many other diseases.

4. In case of sickness, they make most excellent nursing rooms; as they constantly supply a sufficiency of fresh air, so warmed at the same time as to be no way inconvenient or dangerous. A small one does well in a chamber; and, the chimneys being fitted for it, it may be removed from one room to another, as occasion requires, and fixed in half an hour. The equal temper too, and warmth of the air of the room, is thought to be particularly advantageous in some distempers; for it was observed in the winters of 1730 and 1736, when the small-pox spread in Pensylvania, that very few children of the Germans died of that distemper in proportion to those of the English; which was ascribed, by some, to

* My Lord Molesworth, in his account of Denmark, says, "That few or none of the people there are troubled with coughs, catarrhs, consumptions, or such like diseases of the lungs; so that in the midst of winter in the churches, which are very much frequented, there is no noise to interrupt the attention due to the preacher. I am persuaded (says he) their *warm stoves* contribute to their freedom from these kind of maladies." page 91.

the

the warmth and equal temper of air in their stove-rooms, which made the disease as favourable as it commonly is in the West Indies. But this conjecture we submit to the judgment of physicians.

5. In common chimneys, the strongest heat from the fire, which is upwards, goes directly up the chimney, and is lost; and there is such a strong draught into the chimney that not only the upright heat, but also the back, sides, and downward heats are carried up the chimney by that draught of air; and the warmth given before the fire, by the rays that strike out towards the room, is continually driven back, crouded into the chimney, and carried up by the same draught of air. But here the upright heat strikes and heats the top plate, which warms the air above it, and that comes into the room. The heat likewise, which the fire communicates to the sides, back, bottom, and air-box, is all brought into the room; for you will find a constant current of warm air coming out of the chimney-corner into the room. Hold a candle just under the mantle-piece, or breast of your chimney, and you will see the flame bent outwards: by laying a piece of smoaking paper on the hearth, on either side, you may see how the current of air moves, and where it tends, for it will turn and carry the smoke with it.

6. Thus, as very little of the heat is lost, when this fire-place is used, *much less wood** will serve you, which is a considerable advantage where wood is dear.

7. When

* People who have used these fire-places, differ much in their accounts of the wood saved by them. Some say five-sixths, others three-fourths, and others much less. This is owing to the great difference there was in their former fires; some (according to the different circumstances of their

 rooms

7 When you burn candles near this fire-place, you will find that the flame burns quite upright, and does not blare and run the tallow down, by drawing towards the chimney, as against common fires.

8. This fire-place cures most smoaky chimneys, and thereby preserves both the eyes and furniture.

9. It prevents the fouling of chimneys; much of the lint and dust that contributes to foul a chimney being, by the low arch, obliged to pass through the flame, where it is consumed. Then, less wood being burnt, there is less smoke made. Again, the shutter, or trap-bellows, soon blowing the wood into a flame, the same wood does not yield so much smoke as if burnt in a common chimney: for as soon as flame begins, smoke in proportion ceases.

10. And if a chimney should be foul, it is much less likely to take fire. If it should take fire, it is easily stifled and extinguished.

11. A fire may be very speedily made in this fire-place by the help of the shutter, or trap-bellows, as aforesaid.

12. A fire may be soon extinguished, by closing it with the shutter before, and turning the register behind, which will stifle it, and the brands will remain ready to rekindle.

13. The room being once warm, the warmth may be retained in it all night.

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rooms and chimneys) having been used to make very large, others middling, and others, of a more sparing temper, very small ones: while in these fire-places (their size and draught being nearly the same, the consumption is more equal. I suppose, taking a number of families together, that two-thirds, or half the wood, at least, is saved. My common room, I know, is made thwice as warm as it used to be, with a quarter of the wood I formerly consumed there.

14. And

14. And lastly, the fire is so secured at night, that not one spark can fly out into the room to do damage.

With all these conveniences, you do not lose the pleasing sight nor use of the fire, as in the Dutch stoves, but may boil the tea-kettle, warm the flat-irons, heat heaters, keep warm a dish of victuals by setting it on the top, &c.

Objections answered.

There are some objections commonly made by people that are unacquainted with these fire-places, which it may not be amiss to endeavour to remove, as they arise from prejudices which might otherwise obstruct, in some degree, the general use of this beneficial machine. We frequently hear it said, *They are of the nature of Dutch stoves*; *stoves have an unpleasant smell*; *stoves are unwholesome*; *and, warm rooms make people tender, and apt to catch cold.*—As to the first, that they are of the nature of Dutch stoves, the description of those stoves, in the bginning of this paper, compared with that of these machines, shows that there is a most material difference, and that these have vastly the advantage, if it were only in the single article of the admission and circulation of the fresh air. But it must be allowed there may have been some cause to complain of the offensive smell of iron stoves. This smell, however, never proceeded from the iron itself, which, in its nature, whether hot or cold, is one of the sweetest of metals, but from the general uncleanly manner of using those stoves. If they are kept clean, they are as sweet as an ironing-box, which though ever so hot, never offends the smell of the nicest lady: but it is common to let them be greased, by setting candlesticks on

 them,

them, or otherwise; to rub greasy hands on them; and, above all, to spit upon them, to try how hot they are, which is an inconsiderate filthy unmannerly custom; for the slimy matter of spittle drying on burns and fumes when the stove is hot, as well as the grease, and smells most nauseously, which makes such close stove-rooms, where there is no draught to carry off those filthy vapours, almost intolerable to those that are not from their infancy accustomed to them. At the same time nothing is more easy than to keep them clean; for when by any accident they happen to be fouled, a lee made of ashes and water, with a brush, will scour them perfectly: as will also a little strong soft soap and water.

That hot iron of itself gives no offensive smell, those know very well who have (as the writer of this has) been present at a furnace when the workmen were pouring out the flowing metal to cast large plates, and not the least smell of it to be perceived. That hot iron does not, like lead, brass, and some other metals, give out unwholesome vapours, is plain from the general health and strength of those who constantly work in iron, as furnace-men, forge-men, and smiths; that it is in its nature a metal perfectly wholesome to the body of man, is known from the beneficial use of chalybeate or iron-mine-waters; from the good done by taking steel filings in several disorders; and that even the smithy water in which hot irons are quenched, is found advantageous to the human constitution.---The ingenious and learned Dr. Desaguliers, to whose instructive writings the contriver of this machine acknowledges himself much indebted, relates an experiment he made to try whether heated iron would yield unwholesome

2 vapours,

vapours: he took a cube of iron, and having given it a very great heat, he fixed it so to a receiver, exhausted by the air-pump, that all the air rushing in to fill the receiver, should first pass through a hole in the hot iron. He then put a small bird into the receiver, who breathed that air without any inconvenience, or suffering the least disorder. But the same experiment being made with a cube of hot brass, a bird put into that air died in a few minutes. Brass, indeed, stinks even when cold, and much more when hot; lead, too, when hot, yields a very unwholesome steam; but iron is always sweet and every way taken is wholesome and friendly to the human body—except in weapons.

That warmed rooms make people tender, and apt to catch cold, is a mistake as great as it is (among the English) general. We have seen in the preceding pages how the common rooms are apt to give colds; but the writer of this paper may affirm from his own experience, and that of his family and friends who have used warm rooms for these four winters past, that by the use of such rooms, people are rendered *less liable* to take cold, and, indeed, *actually hardened.* If sitting warm in a room made one subject to take cold on going out, lying warm in bed, should by a parity of reason, produce the same effect when we rise. Yet we find we can leap out of the warmest bed naked, in the coldest morning, without any such danger; and in the same manner out of warm cloaths into a cold bed. The reason is, that in these cases the pores all close at once, the cold is shut out, and the heat within augmented, as we soon after feel by the glowing of the flesh and skin. Thus no one was ever known to catch cold by the use of the cold bath: and are not cold baths allowed to harden

the

the bodies of those that use them? Are they not therefore frequently prescribed to the tenderest constitutions? Now every time you go out of a warm room into the cold freezing air, you do as it were plunge into a cold bath, and the effect is in proportion the same; for (though perhaps you may feel somewhat chilly at first) you find in a little time your bodies hardened and strengthened, your blood is driven round with a brisker circulation, and a comfortable steady uniform inward warmth succeeds that equal outward warmth you first received in the room. Farther to confirm this assertion, we instance the Swedes, the Danes, and the Russians: these nations are said to live in rooms, compared to ours, as hot as ovens*; yet where are the hardy soldiers, though bred in their boasted cool houses, that can, like these people, bear the fatigues of a winter campaign in so severe a climate, march whole days to the neck in snow, and at night entrench in ice as they do?

The mentioning of those northern nations, puts me in mind of a considerable *public advantage* that may

* Mr. Boyle, in his experiments and observations upon cold, *Shaw's Abridgement*, Vol. I. p. 684, says, " It is remarkable, that while the cold has strange and tragical effects at Moscow, and elsewhere, the Russians and Livonians should be exempt from them, who accustom themselves to pass immediately from a great degree of heat, to as great an one of cold, without receiving any visible prejudice thereby. I remember being told by a person of unquestionable credit, that it was a common practice among them, to go from a hot stove, into cold water; the same wes also affirmed to me by another who resided at Moscow. This tradition is likewise abundantly confirmed by Olearius."—" It is a surprising thing, says he, to see how far the Russians can endure heat; and how, when it makes them ready to faint, they can go out of their stoves, stark naked, both men and women, and throw themselves into cold water; and even in winter wallow in the snow."

arise

arise from the general use of these fire-places. It is observable, that though those countries have been well inhabited for many ages, wood is still their fuel, and yet at no very great price; which could not have been, if they had not universally used stoves, but consumed it as we do, in great quantities, by open fires. By the help of this saving invention our wood may grow as fast as we consume it, and our posterity may warm themselves at a moderate rate, without, being obliged to fetch their fuel over the Atlantic; as, if pit-coal should not be here discovered (which is an uncertainty) they must necessarily do.

We leave it to the *political arithmetician* to compute how much money will be saved to a country, by its spending two-thirds less of fuel; how much labour saved in cutting and carriage of it; how much more land may be cleared by cultivation; how great the profit by the additional quantity of work done, in those trades particularly that do not exercise the body so much, but that the workfolks are obliged to run frequently to the fire to warm themselves: and to physicians to say, how much healthier thick-built towns and cities will be, now half-suffocated with sulphury smoke, when so much less of that smoke shall be made, and the air breathed by the inhabitants be consequently so much purer. These things it will suffice just to have mentioned; let us proceed to give some necessary directions to the workman who is to fix or set up these fire-places.

Directions to the Bricklayer.

The chimney being first well swept and cleansed from soot, &c. lay the bottom plate down on the hearth, in

in the place where the fire-place is to stand, which may be as forward as the hearth will allow. Chalk a line from one of its back corners round the plate to the other corner, that you may afterwards know its place when you come to fix it; and from those corners, two parallel lines to the back of the chimney: make marks also on each side, that you may know where the partition is to stand, which is to prevent any communication between the air and smoke. Then, removing the plate, make a hollow under it and beyond it, by taking up as many of the bricks or tiles as you can, within your chalked lines, quite to the chimney-back. Dig out six or eight inches deep of the earth or rubbish, all the breadth and length of your hollow; then make a passage of four inches square (if the place will allow so much) leading from the hollow to some place communicating with the outer air; by *outer air* we mean air without the room you intend to warm. This passage may be made to enter your hollow on either side, or in the fore part, just as you find most convenient, the circumstances of your chimney considered. If the fire-place is to be put up in a chamber, you may have this communication of outer air from the stair-case; or sometimes more easily from between the chamber floor, and the ceiling of the lower room, making only a small hole in the wall of the house entering the space betwixt those two joists with which your air-passage in the hearth communicates. If this air passage be so situated as that mice may enter it, and nestle in the hollow, a little grate of wire will keep them out. This passage being made, and, if it runs under any part of the earth, tiled over securely, you may proceed to raise your false back. This may be of four inches or two inches thick-

ness,

ness, as you have room, but let it stand at least four inches from the true chimney-back. In narrow chimneys this false back runs from jamb to jamb, but in large old-fashioned chimneys, you need not make it wider than the back of the fire-place. To begin it, you may form an arch nearly flat, of three bricks end to end, over the hollow, to leave a passage the breadth of the iron fire-place, and five or six inches deep, rounding at bottom, for the smoke to turn and pass under the false back, and so behind it up the chimney. The false back is to rise till it is as high as the breast of the chimney, and then to close over to the breast*; always observing, if there is a wooden mantle-tree, to close above it. If there is no wood in the breast, you may arch over and close even with the lower part of the breast. By this closing the chimney is made tight, that no air or smoke can pass up it, without going under the false back. Then from side to side of your hollow, against the marks you made with chalk, raise a tight partition, brick-on-edge, to separate the air from the smoke, bevelling away to half an inch the brick that comes just under the air-hole, that the air may have a free passage up into the air-box: lastly, close the hearth over that part of the hollow that is between the false back and the place of the bottom plate, coming about half an inch under the plate, which piece of hollow hearth may be supported by a bit or two of old iron-hoop; then is your chimney fitted to receive the fire-place.

To set it, lay first a little bed of mortar all round the

* See page 240, where the trap-door is described that ought to be in this closing.

edges

edges of the hollow, and over the top of the partition: then lay down your bottom plate in its place (with the rods in it) and tread it till it lies firm. Then put a little fine mortar (made of loam and lime, with a little hair) into its joints, and set in your back plate, leaning it for the present against the false back: then set in your air-box, with a little mortar in its joints; then put in the two sides, closing them up against the air-box, with mortar in their grooves, and fixing at the same time your register: then bring up your back to its place, with mortar in its grooves, and that will bind the sides together. Then put in your front plate, placing it as far back in the groove as you can, to leave room for the sliding plate: then lay on your top plate, with mortar in its grooves also, screwing the whole firmly together by means of the rods. The capital letters A B D E, &c. in the annexed cut, shew the corresponding parts of the several plates. Lastly, the joints being pointed all round on the outside, the fire-place is fit for use.

When you make your first fire in it, perhaps if the chimney be thoroughly cold, it may not draw, the work too being all cold and damp. In such case, put first a few shovels of hot coals in the fire-place, then lift up the chimney-sweeper's trap-door, and putting in a sheet or two of flaming paper, shut it again, which will set the chimney a drawing immediately, and when once it is filled with a column of warm air, it will draw strongly and continually.

The drying of the mortar and work by the first fire may smell unpleasantly, but that will soon be over.

In some shallow chimneys, to make more room for the false back and its flue, four inches or more of the chimney back may be picked away.

Let the room be made as tight as conveniently it may

be, so will the outer air, that must come in to supply the room and draught of the fire, be all obliged to enter through the passage under the bottom plate, and up through the air-box, by which means it will not come cold to your backs, but be warmed as it comes in, and mixed with the warm air round the fire-place, before it spreads in the room.

But as a great quantity of cold air, in extreme cold weather especially, will presently enter a room if the door be carelessly left open, it is good to have some contrivance to shut it, either by means of screw hinges, a spring, or a pulley.

When the pointing in the joints is all dry and hard, get some powder of black lead (broken bits of black lead crucibles from the silver-smiths, pounded fine, will do) and mixing it with a little rum and water, lay it on, when the plates are warm, with a hard brush, over the top and front-plates, part of the side and bottom-plates, and over all the pointing; and, as it dries, rub it to a gloss with the same brush, so the joints will not be discerned, but it will look all of a piece, and shine like new iron. And the false back being plaistered and white-washed, and the hearth reddened, the whole will make a pretty appearance. Before the black lead is laid on, it would not be amiss to wash the plates with strong lee and a brush, or soap and water, to cleanse them from any spots of grease or filth that may be on them. If any grease should afterwards come on them, a little wet ashes will get it out.

If it be well set up, and in a tolerable good chimney, smoke will draw in from as far as the fore part of the bottom plate, as you may try by a bit of burning paper.

People are at first apt to make their rooms too warm, not imagining how little a fire will be sufficient. When

When the plates are no hotter than that one may just bear the hand on them, the room will generally be as warm as you desire it.

CLX.

TOPICAL DISCUSSIONS.

TOPIC NO. I.

"Why should a steam-heating contractor, working under plans and specifications of an expert consulting engineer, be compelled, under his contract or any clause in the specifications, to guarantee the working of his job, the temperature, or the specific amount of air, etc., for the heating or ventilating of any particular room in the structure?"

Mr. Barron: The author of that question doesn't realize its bearing. That is a question for a lawyer to decide. We have discussed it here time after time.

President Kent: The time to keep out of an impossible performance is before the contract is signed. We can decide we don't like that sort of contract, but if we sign it the courts will enforce it.

Mr. Wolfe: It seems to me it is entirely a matter of contract.

Mr. Payne: This is a Society of Heating and Ventilating Engineers, and I hardly think any of us would draw a specification and put in a clause that the contractor would have to guarantee the apparatus. I see such specifications floating around. The man who is paid for the work should be the man who stands behind his work. There is hardly one in this room who would attempt to draw plans and specifications and say of the fellow who screws up the pipe, "I will guarantee his work."

Mr. Scollay: The last gentleman's remarks do not alter the question. The fact is—the thing is done. Specifications are prepared and plans drawn up by a consulting engineer and bids are opened and the contract awarded to the successful bidder. He is confronted with a clause of that kind, and after it is all done, after he has followed the plan and specifications, there may be a radiator or some part that will not work, simply because the radiator is too large for the connection. The contractor has followed the plan and has done as the expert has told him to. If

he has been foolish enough to sign a contract it is up to the contractor to make good. The fact is, the expert will worm out of it if he can. I think the question should be discussed further.

Mr. Brennan: That question to my mind is a very long one, and a hard one to answer, because no matter how careful the heating engineer would be in making the plans he may miss-figure himself, and the only right way would be for the man who takes the contract to check up all the plans and specifications. If the engineers would submit plans to the contractor he would call their attention to certain things and they would say you make it right. All we want is that result, and you fix it so it will give it. There are many men who will make plans and specifications and submit them to the architect, and if the heating man don't put them in the architect will. It is up to the man who takes the contract to make the work good.

Mr. Rutzler: The work must be done as laid out. We insist on the work being done that way, and why should we hold the contractor responsible? There are too many cases of people calling themselves experts and putting in a guarantee. They don't allow you to deviate from that plan and specification one iota. But in the end, if trouble comes, they say it is the contractor. If you try to do it after your own ideas, Mr. Expert says: "We won't allow that to be done that way, we want to know how you are going to do it." This expert is paid for his services, and he ought to live up to and guarantee the working of his plans. I have had many contracts with this guarantee in, and it is only of recent date I have stricken it out. They say afterward, "If you didn't think it would work you ought to have said so or done something else." How can we do it in competition? In competition we get our plans and specifications and bid against one another, and I say any man who puts himself up as an expert, capable of laying out a steam-heating apparatus of any kind, should hold himself responsible.

Some years ago I made out a plan and specification for a large building in New York. The architect said the specification was all right, but he didn't see any guarantee there. I said: "What do you want a guarantee for?" "Well, that everything will be right when it is done." I said: "Have you confidence in me?" He said: "Yes." I said, "I figure that that thing when done according to the specification will be right or I will be responsible

for it. I will guarantee it will work and give you satisfaction." I think any man who calls himself an expert should stand responsible for his plan and specification without calling upon the contractor to guarantee what he has laid out.

Mr. Barron: Mr. Rutzler has mentioned a specific case and a specific case you cannot deal with. Every engineer will agree with him in a case similar to the one he has described the engineer should take the responsibility.

President Kent: What are you going to do when the engineer hasn't any finances to back up a guarantee?

Mr. Barron: Put up a bond.

President Kent: Nobody will give him a bond.

Mr. Barron: There are many cases as Mr. Rutzler describes, but there are other cases. Those cases you cannot cover without the necessity of a guarantee from the man who takes the contract. It is up to him, of course. If he bargains to make the apparatus a success—it is a question which in the end goes to the lawyer—and the man who does the work should be responsible and guarantee it will be successful in operation.

Mr. Brennan: There are so many kinds of contracts and so many different people who are doing this kind of work, not in the heating business but general building business, some good might come by having a certain formula or agreement with the different contractors or heating and ventilating engineers to be signed when they take the contract. A great many general contractors, carpenters, masons, etc., have a certain printed contract that they fill out and sign.

Mr. Payne: Do you know the conditions governing the responsibility of the architect who designs a building, and the contractor who builds it, if that building is not what it should be? Who is responsible?

Mr. J. H. Davis: Here is one point of view. Suppose an engineer does design a first-class plant in every respect. The owner goes to work and takes a number of bids from all sorts of people without regard to their responsibility and lets the contract to the lowest bidder. In a great majority of the cases this low bidder takes the work at or below cost, and the moment he gets the contract he goes to work to see how it can be cheapened in every way. The consulting engineer who is paid only a small fee for the plans and specifications does not get enough to pay him to put a super-

intendent on the building to watch the work as it goes in, and can only inspect a small portion of it. The result is that there are a great many defects that creep in, and he knows it, and he knows that it is likely to occur, and in order to protect himself he puts a guarantee clause in the specifications and advises the owner not to sign a contract without it, and from my point of view I think he is right.

President Kent: That is the custom, isn't it?

Mr. Davis: Yes, sir.

Mr. Barron: In every case the contractor is responsible. There is not an architect in New York who is responsible for any structure. I will make that broad statement, but it is a fact—the majority of architects are not responsible in any shape or manner. Most of those who furnish plans don't even inspect the construction of the building.

Mr. Donnelly: Mr. Davis's remarks about materials brings in another question. It is customary in all contracts to put in a clause that the contractor shall be responsible for the period of one year, etc., and that the materials and workmanship must be right and according to specifications. The other question is whether you should guarantee the result of the heating apparatus, and that is entirely different. One is technical and the other is mechanical. In this connection I want to bring up for illustration a case where a firm sued for a bill; the contractor having guaranteed the apparatus would work in zero weather. The winter passed—in New York—and no zero weather. The man sued, but the jury refused to give a verdict because the apparatus was not tested and the contractor must wait for zero weather. That is probably familiar to most of the members and is why this uniform contract was adopted. The contracting engineers have usually a safeguarding clause that the contractor must accept the sizes of radiators and other apparatus as minimum sizes, and if they are not large enough to properly perform their respective functions he is at liberty to increase them to any size he may see fit. That has been in contracts a great deal and throws the responsibility of re-figuring and checking up upon the contractor and might be fairer than the other.

Mr. Payne: I thank Mr. Barron for his reply. What he said, that the architects don't guarantee the structure but hold the contractor responsible, will not upset my argument.

Mr. J. H. Davis: It is rare that the heating and ventilating engineer has a chance to say who shall be awarded the contract. If he were allowed to see that the contract is awarded to good responsible firms, parties whom he knew would do the work properly and in accordance with his plans and specifications, things would be done in a manner that would be more satisfactory to both the owner and the consulting engineer, but, as a rule, he has little or nothing to say in the matter, and therefore must protect himself as best he can.

Mr. Rutzler: There is one prominent man in New York—I am under the impression he is a member of this Society. He called for a certain fan, such and such a width, to deliver so many cubic feet of air, and the fan contractor must guarantee that fan will deliver that air. Nobody can hold us on a condition of that kind. Our margin is too small. But if you put yourselves up as expert engineers, see that you get what you want, then accept the responsibility, and don't put it on the contractor to guarantee what you say you will have and must have.

Secretary Mackay: I made plans for some large work, the fortunate contractor immediately tried to make some changes in it, he said he would not guarantee the working of the apparatus. The owner said he had employed me to make the plans and specifications and the contractor had to do the work according to the specifications. He had his opportunity to figure on it. The heating contractor has to guarantee the satisfactory operation of the plant in some cases, but if in the judgment of the heating contractor any part of the apparatus is not of sufficient capacity he is privileged before he estimates to extend it where he may see fit. But in no case must the apparatus be smaller than that specified—radiators, mains, boilers or any other part.

President Kent: Mr. Barron, did you ever know a case where the consulting engineer was held financially responsible?

Mr. Barron: I did not.

President Kent: Did any one else?

Mr. Scollay: I know where a verdict was obtained against an architect for a mistake made.

President Kent: Probably a case of malpractice—like that of a physician.

Mr. Scollay: Possibly. I do not know.

Mr. Rutzler: I know a case where the architect gave out plans

for a building—it was to cost so much. He had an expert to lay out the heating apparatus, etc. I was the unfortunate contractor. I had to fight and got the enmity of the architect. The owner said, You have agreed to erect this building for so much money, and you have laid out your plans for your pumps and heating apparatus and everything and that is all we will pay you; don't come to us for any changes—just complete the building for the amount. Why should they not be held responsible? Are they experts in their line? If they are and they lay out a building on a certain piece of ground, giving all the details, why should not they be held responsible as much as we are? We are held responsible. If this expert tells me I must do so and so, and I cannot buy a fan two inches shorter or two inches longer, or put in a radiator one section less or four sections more, or cannot run a pipe one-and-a-quarter or one-and-a-half when he says two-inch or one-inch, then hold him responsible. Don't hold me. Why should they hold me? If you are men capable of laying out this work, and put yourselves up for that purpose, then you should be held responsible for it.

Mr. Harvey: I know of a piece of work in Michigan where the architect specified a certain amount of heating surface, and also inserted that clause that the contractor was to guarantee perfect satisfaction of the heating apparatus. It did not give satisfaction. It went before the Circuit Court and the decision was that as the architect had been employed and specified what was required for the heating of that building, and a number of contractors had figured on the same specifications, taking it for granted the architect knew his business—there was not sufficient heating surface—the case was decided in favor of the contractor. It was then carried to the Supreme Court, which decided with the lower court.

Mr. Rutzler: Where an engineer specifies a certain thing and says put in so many feet of radiation, etc., he should be held responsible. I know of a case in New York where specifications were strongly drawn and instructed the contractor to put in so much pipe. There was a clause where it said it was guaranteed to heat the building. The contractor not knowing anything about it signed the contract because he looked at the plans the architect drew. After the job was started up it would not heat the building. Why? Because when they presented the plans to the board

they found the construction would not pass, and they had to alter the ceiling. The consequence was they had to put in extra boilers and more radiation.

Mr. B. H. Carpenter: I don't see the use of having plans laid out at all if we have to refigure them. We figure what we would put it in for to guarantee it. We pay attention to locations, etc., and we refigure the whole thing. Then put it in as we would guarantee it.

Mr. Scollay: Take the case of plans and specifications of the Board of Education in New York and plans and specifications prepared by the United States Government, if you finish the work according to the plans they would pay the expense of any alterations in connection with it.

Mr. Gormly: It is customary when a man agrees to erect a building according to plans and specifications to do it without a guarantee. But if he guarantees results will it cost much more? Specifications frequently say: "The building must be completed in a satisfactory manner," but don't say who shall be satisfied, and it is an awfully hard thing to satisfy some people, no matter how the house is heated. I have also seen in specifications in our city, "the heating contractor must be responsible for any damage to the building while his work is under construction." Suppose there was an explosion in the building, they could hold him. The whole thing boils itself down to this: that a business man should not sign a thing that will commit him to a foolish contract. If there is something foolish in it, he should call attention to it and refuse to sign.

Mr. Barron: I think we should get the architects to remodel their specifications and forms. When I made my remarks a few minutes ago I had in my mind some men who are contractors acting as consulting engineers who are not here this afternoon. And some engineers who act as consulting engineers are here. It is an awfully complex question, and there are two sides to it. We don't want to forget the side of the owner. Who is the owner going to make responsible for the performance of the work? That is the most important part. Anything the parties to the contract do will have to be passed on by the lawyer and receive legal sanction.

Mr. James Mackay: It seems to me we are spending much time on this subject. I know of many cases where reputable

architects have made mistakes in designing a building and have corrected their own errors. I think there are few if any consulting engineers who design heating and ventilating apparatus, stipulating sizes, dimensions and results expected, and superintend the installation who are not perfectly willing to be responsible for their work. I think there are few instances to the contrary. If a heating contractor is willing to assume all responsibility, he alone must decide.

Mr. Scollay: The question as originally framed was based on the supposition that the man who prepared these particular plans and specifications was a consulting engineer and that was his sole occupation.

Secretary Mackay: It seems to be an injustice to the contractor to ask him to figure on plans, and then when he comes to sign the contract ask him to sign a guarantee. That seems unfair. But if the man knew before he figured that the guarantee was expected, then in his position as contractor he should figure on sufficient to cover the guarantee.

Mr. James Mackay: The trouble with that is it results in a lack of uniformity. One contractor may figure on one thousand feet more surface than somebody else. But when contractors figure from a given set of specifications they are at liberty to increase the surface but must guarantee results.

Mr. R. C. Carpenter: If a contractor has to take another man's specifications and is to build in accordance with those plans he should not have to take the responsibility.

President Kent: That is the general idea of the consulting engineer. Specifications with a guarantee to heat a building 70 degrees in zero weather without any provision for a test at a temperature higher than zero are relics of antiquity, but we haven't yet got away from them. I think the trouble will be eliminated if the contractors will refuse to sign such contracts.

Mr. Rutzler: You take a plan where every plate is marked, where the boilers are marked and the specification calls for the size of the boiler, there is no reason why I should think for a moment I was responsible for that work when I understand it was laid out by an expert. We will say I was ordered to put in a 150 H. P. boiler. Would that expert allow me to put in a 100 H. P. boiler if I thought it would do the work? He would say, "No, you are not fulfilling your contract. Put in a 150 H. P."

"If you don't order these goods," he says, "I will order them and charge them to you." It is all right. We don't want to get into that trouble. I don't want to get into any law suits. I would as leave sacrifice some of my contracts. But at the same time I think if they are experts they should assume the responsibility; if I lay out a contract and if I have to take out a 250 H. P. boiler afterwards, after I was paid for the work, that would be my fault, if I made the mistake. I would expect to put in all I said. It is all very well to go to these country places and say we "guarantee" it. It is a very simple thing to guarantee a house job. Mr. Carpenter may prepare a plan for somebody and the architect sends that plan to me and wants an answer in three days. I am anxious to estimate. I figure upon every thing in that plan and expect to give you every cent's worth. But there is a little joker—to guarantee this. This must be somebody's fan and must deliver so many feet of air. Why not say supply a fan that will deliver so many feet of air? Why not say supply a boiler that will guarantee to turn out 100 H.-P.? It is all well to sit here and say I had no business to sign such a contract, but I have signed such a contract, and under one of your prominent engineers of this organization, too, and they bring in this joker and say "so and so." I told them it would not work. When they find it don't work—"you guaranteed that."

Mr. Wolfe: The engineer's commission will not enable him to guarantee the work.

Mr. B. H. Carpenter: In either case I think it is a matter that should come out of the profits of the engineer or out of the contractor's profit and loss. I do not see that it makes any difference.

Mr. Barron: I understand that in Chicago an engineering department of a company makes plans for various architects and the architects assume responsibility for the specifications. In that case you have to find the architect. All these things being considered, you have to go back and look at the matter from the owner's standpoint.

TOPIC NO. 2.

"Is there any advantage in placing check valves on return connections of steam coils, discharging into a single down pipe from an overhead steam main, returning to a receiver, and if so, *is there an advantage* of using check valves of smaller size than the return connections?"

DISCUSSION.

Mr. A. M. Feldman: I designed and installed last year in a factory an overhead single pipe system with long coils and wall radiators. Each coil and radiator was provided with a top steam and bottom return connection to the same riser.

To simplify the shutting and opening of the coils and facilitate circulation, I used a valve on the steam connection and a check valve on the return connection.

But as some of the coils required 1½-inch and 2-inch return connections it occurred to me that the checks will be too heavy to open and will require much static head to clear the condensation, besides, there will always remain some water in the return connection behind the checks. In addition, on account of its weight, the check will only lift slightly, the discharge will be sluggish and dirt and sediment is bound to accumulate around the seat, and sooner or later the check valve will become inoperative. I reasoned out that if with the same or even a smaller head over the check I would use a small check with a very light disk, it will open fully and the water will pass the restricted opening with higher velocity than in the pipe, thus preventing any possibility of dirt settling around or on the seat.

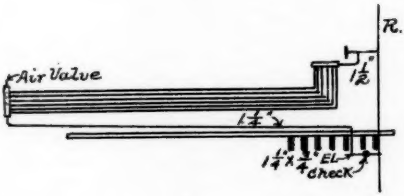
I decided to make an experiment to confirm my reasoning. I rigged up two 30-ft. lengths of 1¼-inch pipe with the usual pitch and a drop leg of 12 inches at the end and placed at the end of one a 1¼-inch check and on the other pipe a ¾-inch check with the back of the disk filed down to make it very light.

At the head of each pipe I had a pail of water. I timed the discharge of an equal quantity of water and found that my surmises were correct, namely, the disk on the 1¼-inch check was heavy and under the full head could not lift up fully; with the diminution of the head the discharge became less and less, and more sluggish, then closed, retaining in the pipe over a quarter of the original quantity of water in the pail. With the ¾-inch

check the water discharged in a full stream—the check fully opened and almost all of the water was discharged, leaving only a couple inches of water in the vertical leg over the check. The time of discharge was also less with the ¾-inch check than with the 1¼ inch.

On the basis of this experiment I installed on the entire job requiring 1, 1¼, 1½, and 2-inch return connections ¾-inch checks. In each case where possible I carried the return connection under the coils above the floor, and near the riser dropped under the floor, thus giving plenty of static head, placing a reducing elbow with the ¾-inch check and a ¾-inch nipple connecting to the riser, as shown in the cut. I specify the seats of the checks to be round instead of square and all the disks to be filed down as much as possible to reduce their weight.

The system has been in operation the second winter very suc-



cessfully. The coils clear themselves practically of all of the water and the checks don't stick.

I made this my practice in all overhead single-pipe systems where long coils or radiators are used. It should be noted, as I stated above, that I use two connections for each coil or long radiators.

Whenever I have to use a very large radiator I install a hot-water radiator, so as to have the top connection for steam. I thus obtain perfect circulation.

I have also with apparent good results followed the same scheme of reducing the customary large check valves on coils of blower systems, namely, having large return connections on each coil but smaller checks near the discharge into the return header.

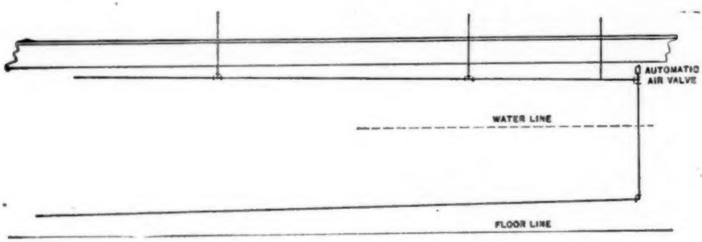
I would like very much to know what were the experiences of other members of the Society along the same lines, or don't they find trouble with large checks?

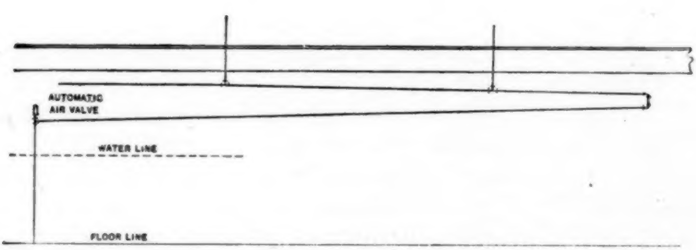
TOPIC NO. 3.

"The advantage of automatically venting the extreme ends of steam mains in the basements on low pressure gravity steam-heating apparatus, and the proper mode of connection."

DISCUSSION.

Secretary Mackay: I suggested that topic because I have found trouble in low-pressure gravity apparatus by improper venting of the steam mains. I have in mind a case where I looked over a job which W. H. Warner, one of the earliest steam men, placed in Albany, N. Y., thirty years ago—a large gravity





apparatus. It was placed according to the two-pipe method, and there were no air-valves in the radiators at all. In that particular apparatus all the dead air in the steam space of the boiler, steam mains in the basement and in the radiators, was dispelled from the system in the basement instead of in the rooms. To-day we are using largely on gravity steam apparatus automatic air-valves that close against heat and water. Following this old practice of Warner's, I have found it was a good thing to take the air from the steam space in your boiler and

discharge it in the cellar instead of in the living rooms. Also, I found it equalized the water line better than if you did not vent it, because you will have times when the radiators are shut off and as a result the water will rise up into your main. I have found the place for the air-valve is on top of the main, as shown, and the water is simply from there down. I think that is a point that is often neglected in gravity apparatus. We depend on the air escaping from the radiators instead of taking it out in the basement. The air-valve will close against water by flotation and against heat by expansion.

Mr. Harding: I put up at a hotel in New England, and they gave me a room at the further end, 200 feet away, and I turned on the steam—I was the only guest in the hotel at the time—it was a very long time before I got any heat. When I went to the table I mentioned it. They put the valve on the end of the steam main before it went to the return, and now they can get steam in the radiators at that end in about one-half the time they did before.

TOPIC NO. 4.

"The advantages and disadvantages attending the use of the thumb rules."

DISCUSSION.

Mr. Berry: Did the Society in past years ever have a paper prepared giving any of the thumb rules for estimating or the methods of determining the size of apparatus, etc.—has that ever been put in a paper?

President Gormly: So far as the Chair knows it never has. I have no doubt the Society would be willing to accept anything of that kind if the gentleman will prepare one.

Mr. Berry: I don't feel competent, but I think there must be some of the older men of the Society who have adopted rules which are accurate enough. There seems to be no way of getting track of such trade secrets.

Mr. Kent: I think our Proceedings are full of these thumb rules, and I think nearly every one uses them. We heard one to-day, that the return should be one size smaller than the steam riser. That, I understand, is a thumb rule and allows a reason-

able profit to the contractor. As to the question of advantages or disadvantages attending the use of the thumb rule, the advantage of the thumb rules is they are exceedingly easy to work with; the disadvantages are that they don't take into consideration all the various circumstances and they are apt to be inaccurate very often. They are good and useful but don't fill the requirements of modern practice.

TOPIC NO. 5.

"The effect of exhaust fans for ventilating rooms heated by direct radiators."

DISCUSSION.

Mr. James Mackay: Some years ago I heard some of the largest manufacturers of radiators of the country make some claim in reference to the use of exhaust fans in rooms heated by direct radiators. I have seen them put fans under a direct radiator and get good results. I do not know that there is anything very reliable or very certain in the way of experiments that has come to my notice upon the subject.

Mr. Quay: Years ago I had occasion to use fans to heat the vestibule of a large store, we used direct radiators, and we did it for two or three reasons, and one was because of the doors and the other was we could not get enough direct radiation. We have found excellent results, and it was not suggested by an engineer either. The merchant himself made the suggestion in reference to the store, and I think it is giving the best results. Where the doors are continually opening and closing there is a strong current of air going, and, of course, it is hard to heat that part of the store. With the fans I was able to get a regular amount of heat in the vestibule. Of course, it was run at a low speed or a high speed to suit conditions. There are a lot of buildings heated with direct radiation, but no ventilation except the cracks in the rooms, and fans installed in these buildings exhaust the air out.

TRANSACTIONS

OF THE

SEMI-ANNUAL MEETING,

Chicago, Ill., July 19 and 20, 1906.

CLXI.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

SEMI-ANNUAL MEETING.

Held at the Auditorium Hotel, Chicago, Illinois, July 19 and 20, 1906.

PROCEEDINGS.

MORNING SESSION, July 19, 1906, 10 o'clock A.M.

The meeting was called to order by President Gormly.

The Secretary called the roll, and reported a quorum present.

The Secretary then read the names of members elected since the last meeting, which are as follows:

Eugene P. Bradley..............	Member.
Joseph H. Brady...............	"
James H. Brown...............	"
Chas. E. Hasey................	"
Elbert O. Haskins..............	"
Geo. D. Hoffman..............	"
Frank E. Kerr.................	"
Allen G. McAvity..............	"
D. F. Morgan.................	"
John Trainor..................	"
Champlain L. Riley............	"
Warren Webster...............	"
Geo. H. Wentz................	"
John Boylston.................	Associate.
E. N. Green...................	"
Gustav A. Dornheim............	Junior.
Edward W. Soleau.............	"

The President: Custom requires the President of this Society to make a few remarks at this time. No doubt this custom was intended to be complimentary, but if the present occupant of the chair was consulted in the matter he would have this part of the proceedings omitted. This is said with no intention to criticise the programme, which appears to be excellent.

We have assembled to advance the interests of ourselves, our Society, and of the public in general. We are giving valuable time, and as life is short it were better to spend our time in the discussion of scientific matters than in listening to a speech from any one. Our purpose will be advanced by thought rather than by words. Thought leads to investigation, investigation leads to experiment, experiment leads to facts—the facts which we have acquired are our most valuable asset.

As we cultivate the habit of thought and the spirit of investigation we will advance in the future even more than our phenomenal advancement has been in the past. One of the greatest pleasures of modern life is to live in a well-heated and ventilated house and to know that your children attend properly heated and ventilated schools. But a few years ago a well-heated house was not to be found; now such buildings are within the reach of all. In a great measure this happy condition was produced mainly by the tireless exertions of the members of The American Society of Heating and Ventilating Engineers. We are the standard bearers of civilization. It has been well said, "The measure of a country's civilization may be gauged by the manner of heating and ventilating its houses." As an illustration of the truth contained in this quotation many of those present have seen the crude effort of the Indian to heat his wigwam; we have also learned how the semi-barbarous Roman heated his dwelling by carrying the smoke-flue back and forth beneath the tile floor of his living room; his method of heating permitted smoke and gas to enter the room to such an extent that the entire family was frequently forced into the open air to obtain sufficient oxygen to sustain life. These systems of heating indicated the culture of those who used them; just as our methods indicate our culture. Thanks to investigation and experiment on the part of our members, well seconded by progressive manufacturers who supplied the goods we required, and aided very materially by the press, which carried the knowledge to every

village and hamlet, we to-day find perfect heating plants throughout the length and breadth of this great country. It is a source of great pleasure to us that we have very materially aided this advancement. Kindred heating societies are doing the same good work in other lands. Many members of our Society are in other countries doing as good work as we are doing here. In justice it should be said, our Society was the pioneer in this work. With a great generosity, unknown to other ages, we cheerfully give any information to members and non-members alike. Our Society is known and honored wherever civilization has penetrated. I trust our deliberations here will benefit the whole human race.

To return to the immediate work in hand and to dispose of it to the best advantage, it will be necessary for our members to confine their thoughts and remarks strictly to matters on the programme. The programme is long, requiring the best use of our time, and is so varied as to include practically all the different applications of heating and ventilating apparatus attracting attention at this time. I extend, on behalf of the Society, a cordial invitation to all present who are interested in the programme to take part in the discussion. The prestige of our Society has secured some courtesies and attention, as will be shown by the communications, which the Secretary will now read.

The Secretary read an invitation from the Western Society of Engineers, dated July 9th, offering the use of the Society's rooms.

The Secretary: I wrote to the Secretary of the Society, thanking him for his courtesy, and mentioning that previous to his making the offer our Society had arranged to meet at this hotel, that in the judgment of the Board of Governors it was possibly better suited to the visiting members.

I have a letter from Mr. Snyder; he had every intention of being present, but at the very last moment he finds it impossible.

Here is a letter from Arthur H. Barker, of Trowbridge, England; he intended to be with us to read his paper, but at the last minute finds it will be impossible to be here.

The Secretary then read letters from some absent members and invited guests, regretting their inability to attend the meeting.

The President: The matter of the application for a charter for a Local Chapter in Chicago will come up this afternoon, and we would like to have a very full and free discussion on it, and we would like to have all the members present to take part in it.

The next business in order is the reading of a paper headed "Heat Losses and Heat Transmission," by Walter Jones, Stourbridge, England, member of the Society. We have asked Prof. J. H. Kinealy to kindly read the paper.

(Prof. Kinealy thereupon read the paper.)

It was discussed by Messrs. Kinealy, Thompson, Donnelly, Lewis, James Mackay, and Widdicombe.

The President: The next subject is topic for discussion No. 1, "The comparative relations between the completeness of air removal and the efficiency of steam radiators." It is now open for discussion.

The topic was discussed by Messrs. Donnelly, Kinealy, Bishop, Hale, Blackmore, and Mallory.

Mr. Hale announced that the Illinois members of the Society had tendered a banquet to the visiting members, to be held in the evening.

The President: Gentlemen, we have had a very good discussion on Topic No. 1. The next topic is Topic No. 2, "The proper air space between the surfaces exposed in the heaters of blower systems." I trust that will prove equally interesting.

The topic was discussed by Prof. Kinealy.

The President: The next topic for discussion is No. 3, "In blower systems of heating and ventilation, what are the maximum allowable velocities in the different parts of the system, and what limits the velocity and why is it limited?"

The topic was discussed by Messrs. McCann and Kinealy.

Topic No. 4, "Summer tests of heating systems," was then discussed by Messrs. Chew, Thompson, May, Kinealy, and Blackmore.

After the discussion, on motion the meeting adjourned to 2.30 P.M.

Afternoon Session, July 19, 1906.

The President: The first business in order, gentlemen, is the preliminary report of special committees. The first committee is on the Standard Sizes of Steam Mains and Returns for Small Buildings, Mr. James A. Donnelly, Chairman.

PRELIMINARY REPORT OF COMMITTEE TO COLLECT DATA ON STANDARD SIZES OF STEAM AND RETURN MAINS.

Our preliminary report at this time is not intended to be at all complete or thorough as to the data that we have thus far collected, but more in the nature of general remarks on the subject, tending to show that the American practice is surprisingly uniform, and that it is very probable that in the near future a standard may be prepared which will represent an average, differing to such a comparatively slight extent from the figures of each individual contributor that it will receive universal and spontaneous indorsement.

The collection of the data for such a standard as this is clearly within the scope of the old saw that " There is safety in numbers "; there is also correctness in an average derived from a large number of answers, and we therefore most earnestly appeal to all those who are interested in this subject, whether they are members of our Society or not, to give us the benefit of their knowledge.

The Committee prepared a set of questions and sent out 500 copies, including one to each member in this country. About fifteen answers were received, all but two of which came from our own members.

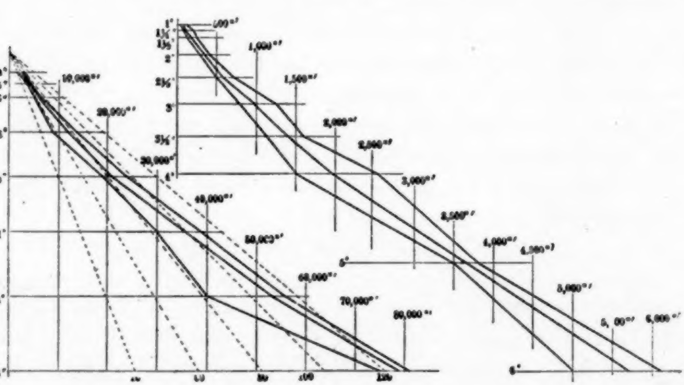
The first question as to size of radiator connections served to bring out an almost unanimous expression of opinion as to agreement with the manufacturers' standard. Most of those who went into details stated that they used nothing smaller than 1¼ in. on one pipe work and several decreased the amounts 20 or 25 per cent.

The compiled results from the answers in regard to maximum amounts of radiation permissible upon low pressure steam mains in plants of moderate size or those not having over 100 ft. run of main is given in the following table and in the diagrams:

	Highest.	Lowest.	Average.
1 inch	100	40	59
1¼ "	125	75	94
1½ "	250	126	171
2 "	400	236	335
2½ "	700	5C0	594
3 "	1,280	800	994
3½ "	1,600	1,100	1,407
4 "	2,560	1,500	1,971
5 "	3,900	3,500	3,655
6 "	6,400	5,000	5,700
8 "	13,500	8,000	11,850
10 "	23,800	15,000	20,950
12 "	40,000	30,000	35,777
14 "	55,600	40,000	53,137
16 "	81,000	75,000	87,437

In the large sizes the answers run remarkably close together; the average difference in the sizes from 5 to 16 in. between the average and the highest answer received being only 7.4 per cent.; in the sizes from 2½ to 16 in. it is 11 per cent., and in all sizes from 1 to 16 in., 15.7 per cent.

The greater disagreement in the smaller sizes arises from the fact that some of those answering state that it is their practice



to put almost double the amount of radiation on a pipe as a steam main than as a radiator connection; while others put less on it as a main.

Many of the answers received do not take up the question of return main sizes at all, and those that do differ to a considerable extent.

Almost all agree that the adoption of a standard would be desirable and beneficial to the profession.

QUESTIONS OF COMMITTEE TO COLLECT DATA ON STANDARD SIZES OF STEAM MAINS AND RETURNS.

A committee was appointed at the last meeting of the American Society of Heating and Ventilating Engineers to collect data on Standard Sizes of Low Pressure Steam Mains and Returns and we are submitting the accompanying paper and list of questions to you for the purpose of collecting this information.

We think there may be a variance of opinion as to the proper size steam main for a given amount of radiation where the run is long, but that it may be possible to adopt as a standard the amounts generally in use at the present time for the average installation where the run is short or not over one hundred feet.

Thus though it may not be advisable in all plants to put as much radiation on a pipe as given in the standard, yet we can adopt a maximum amount and agree that it is never advisable to exceed it.

We would like you to answer the questions as fully and as much in detail as possible and add any information you may have on the subject.

QUESTIONS.

1. Do you use the standard sizes of radiator connections for low pressure steam work, as published in Manufacturers' Catalogues?

2. If your practice differs, please indicate it on the accompanying tables.

3. Please state whether your practice differs from Table II. of the maximum amounts of direct radiation permissible upon pipes of the corresponding sizes for low pressure steam work and give the amounts which you use in your practice?

What allowance do you make for extra long or crooked steam lines?

TABLE I.

Two Pipe.			One Pipe.	
1 inch pipe	48 square feet	¾ inch return.	1 inch	24 square feet.
1¼ " "	96 " "	1 " "	1¼ "	60 " "
1½ " "	160 " "	1¼ " "	1½ "	100 " "
2 " "	360 " "	1½ " "	2 "	230 " "

TABLE II.

Steam Main.	Square Feet of Heating Surface.	Dry Return.	Wet Return.
1 inch pipe	40	¾ inch.	¾ inch.
1¼ " "	75	1 "	¾ "
1½ " "	126	1 "	1 "
2 " "	286	1¼ "	1 "
2½ " "	535	1½ "	1 "
3 " "	890	1½ "	1 "
3½ " "	1,360	2 "	1 "
4 " "	1,950	2 "	1 "
5 " "	3,600	2½ "	1¼ "
6 " "	5,900	3 "	1½ "
8 " "	12,700	4 "	2 "
10 " "	22,300	5 "	2½ "
12 " "	37,000	6 "	3 "
14 " "	55,300	7 "	3½ "
16 " "	78,800	8 "	4 "

4. Do you consider that the adoption and use of standard sizes of steam and return mains would aid the heating engineer in the production of better results with steam-heating apparatus?

5. Give any additional data of information that you may have in reference to the above subject.

Respectfully,

J. A. Donnelly,
H. J. Barron,
F. G. McCann.
} Committee.

The Secretary: As this is only a preliminary report it would be well to hear the other two reports and then take some action of the Society in connection with them unless there is some person that wishes to discuss this particular report at this time.

Mr. Chew: I don't know whether all of the men understand what this report means. The Committee on Standards was given a job which took in everything; the result was, as in all work of a general and sweeping nature, nothing of special importance was brought to their attention and very few things were completed, and it was thought that if small committees were given some special work to do, committees composed of men in one place, they could get together and do something. This idea was quite successful in the work of the committee for the collection of furnace data, and that was the reason for the appointment of these other committees. This is a special committee to look into the steam mains and sizes, and it is desirable that all the members correspond with the committee after this

preliminary report is put in their hands, to lend assistance, so that the work would be ultimately made comprehensive, and so that when this report is presented it will be valuable. Every member of the Society is solicited to lend every assistance he can to this committee.

Secretary Mackay: I made this suggestion, that as these three committees report to the Committee on Standards, that while they have done good work so far, it has been suggested that the preliminary reports be printed and forwarded to the members as soon after this meeting as possible, with a request that each member lend his assistance to bringing them up to their idea of the standard, or assisting in standardizing them in time, so that the different committees can have an opportunity of getting their reports completed and forwarded to the Chairman of the Committee on Standards in time for his committee to go over them and bring them to the annual meeting in the shape of a Final Report.

The President: Well, if there is nothing further to be said on Mr. Donnelly's work we will ask for a report now on data on Steam Heating, Mr. J. J. Blackmore.

Mr. Blackmore: I will read the report. I might say, Mr. Chairman, that the committee have been unable to get down to definite work in the way of compiling data, for the reason that it is exceedingly difficult to get matter, and in order that we might get the data from the different parts of the country the committee decided to send a letter to each one of the members, through the Secretary, with a list of questions similar to those sent out last year by the hot-air committee, and this circular will be printed, with a sketch of the first floor plans of a house, the basement and first and second floors and attic, and have a request attached to it that the members answer certain questions relating to it. I suppose in the way of a preliminary report I might read this circular letter, and you will have some idea of what is coming: This will be the circular letter we propose to send to the members.

NEW YORK, *July* 10, 1906.

DEAR SIR:

At the last annual meeting of the American Society of Heating and Ventilating Engineers, held at New York in

January, the question of collecting data on steam heating of small buildings was discussed.

It was generally felt that the records of the Society did not contain, in a concise form, the opinions of enough members to put on our records the general practice in vogue for this class of building.

A committee of three was appointed as follows: J. J. Blackmore, B. H. Carpenter, and A. M. Feldman, to collect data for the use of the Committee on Standards, who will tabulate the data gathered for publication in the *Transactions of the Society.*

The Committee beg that you will carefully read over the enclosed circular, and as far as possible answer all the questions raised, and any more that occur to you, that will throw light on the practice in use in your locality for such buildings. A complete specification for such a building from you, stating how you arrived at the different size radiators and the size boiler, would materially assist.

The questions asked are not complete, but are intended to bring out as far as possible all the salient points in connection with such a heating apparatus. For the purpose of figuring, we will assume the first floor has a 10-foot ceiling, the second 9 foot, and the attic 8 foot.

Trusting you will give this matter your earnest consideration, and give us all the data you have on the subject of steam heating for small buildings, we are,

Very truly yours,

J. J. Blackmore,
B. H. Carpenter, } Committee.
A. M. Feldman.

Mr. Blackmore: It is proposed to have this printed and sent to the various members so that they can digest the various questions and give the committee what assistance they can before the time of the annual meeting, so that the report can be published in full at that time.

The President: Are there any questions, gentlemen, you desire to ask Mr. Blackmore? If not we will pass that matter and take up the next, which is a preliminary report on data on Hot-water Heating, James Mackay, Chairman. Is Mr. Mackay present?

Mr. James Mackay: This is only a preliminary report, giving a synopsis of what we have done. The committee is composed of Mr. Capron, Mr. Lewis, and myself. We have divided the subjects among ourselves. For instance, I have taken the part relating to boilers; Mr. Capron that pertaining to mains, risers and radiator connections; while Mr. Lewis has handled that part pertaining to radiation. The work has been mapped out from time to time at meetings and through inquiries we have made of members of the Society and others in an effort to collect data that would be of interest on the subject. Now these inquiries we have sent out at our own expense. Each individual has borne his share. Mr. Capron sent out a great number of tabulated questions and received a great number of replies; Mr. Lewis did the same. I have not sent out as many, but I have obtained a little information. The report is as follows:

Preliminary Report of Committee to Secure Data on Hot-water Heating.

The committee appointed at the annual meeting of the American Society of Heating and Ventilating Engineers in January to collect data on Hot-water Heating has sent out a large number of inquiries and has received very interesting replies. More inquiries will be sent out from time to time. The subject naturally divides itself into three heads—namely, Boilers, Radiation, Piping.

BOILERS.

We have had poor success in getting data from the boiler manufacturers, because many of them naturally, perhaps, believe that in answering our questions they will be divulging private and valuable information, which, if made public, might injure them. The difference in quality and kinds of fuel in different parts of the country renders the situation still more difficult. We have tabulated the grate surfaces and the rated capacities of a large number of boilers of different types. We feel that data giving the average practice in proportioning grate surface to radiation capacity for the different fuels will be of value.

The committee would like all our members and any interested parties to send us answers to the following questions:

1. What size sectional or C. I. boiler would you use for a hot-

water heating apparatus, containing 2,000 sq. ft. net radiation, in addition to mains, the radiation to be maintained at a temperature of 150 degrees F.?

2. What method do you use in determining the size of boiler required for a given hot-water heating apparatus, involving:

a. Direct radiation.
b. Direct indirect radiation.
c. Indirect radiation?

3. In proportional sectional or C. I. boilers for any given work, do you accept catalogue statements, or have you a method for checking grate areas, heating surfaces, flue surfaces and areas, smoke connections, etc.? If so, please give it.

We would appreciate suggestions for further progress along these lines, or other lines, from the society.

RADIATION.

We have taken a given room under given conditions and sent out inquiries to engineers in this and in foreign countries. Great interest was manifested by nearly all to whom inquiries were sent. The answers are tabulated, and the most interesting methods used in arriving at them will be given.

We have worked back from the most conservative and apparently correct answers and checked up tables of heat transmission, loss, etc., and expect to give an illustration of the means of getting the average result. This method, proved approximately correct for the given case, will by means of the tables give a method of computing the amount of required radiation for unusual conditions.

The committee would like answers to the following questions:

1. A room in a residence is to be heated by hot water, gravity circulation. Temperature of water, 160 degrees. Room is 10 x 10 x 10 ft., two sides exposed. Outside walls brick, 9 in. thick, furred inside. Glass in three windows; aggregate glass surface, 62 sq. ft. Outside temperature, zero. Maximum permissible drop in temperature of water, 20 degrees. Please state amount of direct radiation required if room is to be heated by direct only, and give method used.

2. Please state amount of indirect radiation required if room

is to be heated by indirect only, indirect to be suspended from basement ceiling, with outside air supply, and give method used.

We would be glad of suggestions for further data on this subject than that above outlined.

PIPING.

We have made a large number of inquiries of engineers and contractors in regular practice in installing hot-water plants. These inquiries cover the sizes of mains and connections, the best of the various systems for given conditions, etc.

A list of questions covering the matter of mains is given here. The committee would appreciate answers to all or any of them.

What is your usual practice in laying out work as follows:

Usual size of main supply pipe at boiler supplying 1,800 sq. ft., direct radiation, three story building?

a. With two-pipe circulation, 120-ft. circuit.

b. With one-pipe circulation, 100-ft. circuit.

c. With overhead circulation, closed system, 120-ft. circuit.

d. With overhead circulation, open system.

Usual size of pipe supplying 1,200 sq. ft. of indirect radiation; bottom of radiator 12 in. above top of boiler—

a. With connection direct from boiler to radiator?

b. With overhead circulation, supply pipe running to header?

Is it your usual custom to run supply to indirects direct from boiler, or make connection with basement main, feeding direct radiators above?

Have you noticed any different results in above connections?

Usual size of risers feeding direct radiation 80 sq. ft. first floor, 90 sq. ft. second floor, 60 sq. ft. third floor; 10-ft. ceilings—

a. With up faced circulation having separate return pipe?

b. With overhead circulation, one pipe?

Usual size of riser, supplying 90 sq. ft. direct radiation, second floor; 10-ft. ceiling—

a. With up feed circulation, having separate return pipe?

b. With overhead circulation, one pipe?

Usual size of direct radiator connections, first floor—

a. 30 sq. ft. and under?

b. Not exceeding 60 sq. ft.?

Usual size of direct radiator connections, first floor—

a. Not exceeding 100 sq. ft.?

b. 100 sq. ft. and over?

Usual size direct radiator connections, second floor—

a. 30 sq. ft. and under?

b. Not exceeding 60 sq. ft.?

c. Not exceeding 100 sq. ft.?

d. 100 sq. ft. and over?

Usual size direct radiator connections, third floor—

a. 30 sq. ft. and under?

b. Not exceeding 60 sq. ft.?

c. Not exceeding 100 sq. ft.

d. 100 sq. ft. and over?

IN GENERAL.

We have worked five months on this very interesting subject, and while we expect to have a report at the annual meeting we wish to be sure we are working on the lines intended by the Society at the time of our appointment.

We desire your suggestions and criticism on the above outlined programme, and, further, desire any information which any member may have to suggest along the lines of our researches.

Respectfully submitted,

JAS. MACKAY,
ED. F. CAPRON, } Committee.
S. R. LEWIS.

The idea of having this report printed and sent to our members is a good one, because that puts the questions into the hands of every member and gives us an opportunity to successfully continue our work. Was it contemplated in the appointment of the Committee that the expenses incurred should be borne by the Committee or the Society?

The President: It will be only fair to have it borne by the Society.

Mr. James Mackay: Of course that is a matter we leave to you. The expense is small and none of us begrudge it. In fact, it has afforded us an opportunity of gaining information through channels we were glad to have opened up to us. We think that

the printing and mailing of the report, with the request that answers be sent to some certain person before the next meeting, will result in good, and thus we will be able to prepare a comprehensive report for the annual meeting. We would like to hear some criticism.

Mr. Chew: I would like to congratulate these different committees. They have had better success than the Furnace Committee had; when our questions went out we got one answer from the Society and two from the outside. The Chairman of the Committee is now in Europe; he has some notion that he is still working on, and I think eventually we will have something further to present to the Society that will be valuable and useful.

Mr. James Mackay: Your remarks about your inability to get answers brings up to us the idea that we contemplated just such a difficulty, and to overcome that we couched the questions in very seducting language.

The Secretary: If there is nothing more to be said I would move that these preliminary reports be received and turned over to the Publication Committee, ordered printed and distributed to the members as soon after this meeting as possible, urging the members to reply to them as fully and as expeditiously as possible, so that they may be in the hands of the committees which finish their reports and turned over to the Committee on Standards sixty days previous to the annual meeting.

Mr. James Mackay: I might say that we have tabulated replies to a great many things, but we did not think there were enough of them to present them in tabulated form and call it a complete report, because we expect by printing those questions and getting answers to them, that we can make a more complete report.

Mr. Chew: At another of our semi-annual meetings the Furnace Data Committee refused to report, because they thought it would shut off further information, but I think Mr. Mackay is perfectly right in the course he has pursued. The whole idea of this preliminary report is to make these men familiar with it: they are liable to talk with other folks, if they are printed and distributed among the members, and also to the trade members, and probably two-thirds of the information we will get will come from outside of the Society. Judging from the prom-

ises already made, their report will throw the furnace data report in the shade.

Mr. Hale: I want to ask the Committee if possible why they take 150 degrees in the radiators as their basis for computing the radiation, and whether they dropped 20 degrees.

Mr. James Mackay: I will answer in this way: I would prefer to have made it 180 degrees in the boiler and 170 degrees in the radiators. The questions should have carried the same temperature that Mr. Lewis embodied in his question—namely, 160 degrees—but instead of that it is here given at 150 degrees.

Mr. Blackmore: I suppose it is up to the Chairman of the other Committee to do something. We did not send out these questions yet, we assumed that if we got them in shape for this meeting we were doing pretty good work. If the members, when they get this circular letter, and the questions, will take hold of the subject properly, they can give a great many useful data for the Committee on Standards.

The President: I would like Mr. Mackay to repeat his motion made a few moments ago—it was not seconded. I don't think it was understood.

Secretary Mackay repeated the motion. It was seconded and carried.

The President: The next business in order is the application for a charter for a local chapter of the Society. Discussion on that topic is now in order.

Secretary Mackay read the following letter:

Chicago, July 19, 1906.

To the Board of Governors of the American Society of Heating and Ventilating Engineers.

Gentlemen: We, the undersigned, Illinois Members of the American Society of Heating and Ventilating Engineers, do herewith make application to form a Local Chapter of the Society, headquarters of which should be located at Chicago. Said Chapter to be governed by its local officers in conjunction with the By-laws of the American Society of Heating and Ventilating Engineers and under the supervision of its Board of Governors and such local by-laws as may be found necessary, approved by the parent body. All applicants for membership in the Chapter

shall first be members of the American Society of Heating and Ventilating Engineers.

Yours respectfully,

T. J. Waters,	Jas. Mackay,
Aug. Kehm,	E. F. Capron,
J. M. Stannard,	Geo. Mehring,
John F. Hale,	John K. Allen,
R. A. Widdicombe,	Sam'l G. Neiler,
N. L. Patterson,	W. B. Graves,
S. R. Lewis,	John Boylston.

Secretary Mackay: Of course we can do nothing in the way of granting this application except that a motion would be right at this time, after the matter is thoroughly discussed, to amend the by-laws. We have to amend the by-laws if we do that, according to Article X., which provides that it can be done by amendment. The matter can be arranged in the course of the next three months, or before the annual meeting.

Mr. James Mackay: To bring this matter to a focus, I move that the Board of Governors of the American Society of Heating and Ventilating Engineers be requested to take a mail ballot on this proposition of amendment to the by-laws, permitting local chapters.

The President: Is there any further discussion upon that? If not, we will take a ballot on the motion. It will be understood before we take a ballot that only members can vote; honorary members, and junior members, and associate members are not entitled to vote on the question.

The motion was seconded and carried.

The Secretary: I have this application which I read from the Illinois members, and, if in order, I would move that provided the proposed amendment to the by-laws is carried, that permission to form a local chapter in Illinois be granted.

The President: The motion is made and seconded—you comprehend junior membership in the motion as well?

Mr. James Mackay: Junior and associate members.

The President: Gentlemen, you have heard the motion. Are you ready for the question? Those favoring the motion say "Aye." Those opposed, say "No."

(Motion carried.)

On motion the meeting adjourned till ten o'clock, Friday, July 20.

July 20, 1906, 10 o'clock, A.M.

Met pursuant to adjournment.

The meeting was called to order by the president.

The President: The first order of business is the reading of a paper entitled "Notes on the Use of Feed-water Heaters in Connection with Heating Systems." By William G. Snow, member of the Society.

Mr. Snow read the paper, and it was discussed by Messrs. Donnelly, Stannard and Kinealy.

The President: Is there any further discussion on that question, gentlemen? If not, the next order of business is a paper entitled "Fads and Fallacies in Hot Air Heating." By R. S. Thompson, member of the Society.

Mr. Thompson read the paper, and it was discussed by Messrs. Jones, Lewis, Connolly, Davis, Weinshank, Donnelly, and Schaffer.

The President: The next matter in order is a paper, "The Elimination of Redundant Parts in the Forced Circulation of Hot Water," by A. H. Barker, Trowbridge, England (non-member of the Society), presented by request. Will Prof. Kinealy have the kindness to read that?

Prof. Kinealy read the paper. It was discussed by Messrs. Donnelly and Kinealy.

The President: If there is no further discussion on this paper we will pass to the topic for discussion, Topic No. 5, "Natural *versus* mechanical and upward *versus* downward ventilation for rooms in schools and larger auditoriums."

The topic was discussed by Mr. McCann.

The President: Is there any further discussion on the subject, gentlemen? If not, we will pass now to Topic No. 6, "The advantages attending the use of steam and hot water in heating a number of buildings requiring 150 to 200 horse-power, from a central plant." (No discussion.)

The President: We will proceed to the next topic if there is no discussion on Topic No. 6. Topic No. 7 is, "The best method of calculating the sizes of the mains in a hot water heating plant." The topic is now open for discussion.

The Secretary: That topic could possibly be best answered by our Committee on Hot Water Data; it is along their lines.

The President: Well, if there is no discussion on Topic No. 7 we will proceed to Topic No. 8, "The effect of the size of the mains on the height of the water line in different parts of a gravity heating system." That should bring out some discussion.

Topic No. 8 was discussed by Messrs. McNichol, Donnelly, and Morgan.

Topic No. 9, "The relative economy in fuel of steam, vapor, vacuum, and hot-water heating for residences," was discussed by Messrs. Bishop, Kinealy, Morgan, Donnelly, Brennan, Schaffer, and Secretary Mackay.

Afternoon Session, Friday, July 20, 1906.

The President: The first business in order is a paper entitled "Wall Radiators *versus* Long Pipe Coils," by J. A. Donnelly.

The paper was presented by Mr. Donnelly and briefly discussed by Messrs. Kerr and Harvey.

The President: We will now pass to the next paper in order, "An Improved Application of Hot Air Heating," by Mr. A. O. Jones.

The paper was read by Mr. Jones and discussed by Messrs. Donnelly and Chew.

PROCEEDINGS.

The President: We will now take up Topic No. 10, "The relation of heat units per cubic foot and the cost of gas to its economical and possible use in heating water."

The topic was discussed by Mr. Thompson.

Topic No. 11, "In a hot air furnace burning five pounds of anthracite coal per square foot of grate per hour, what proportion of heating surface should be provided in relation to the grate surface to insure economy and efficiency," was then briefly discussed by Mr. Jones.

Topic No. 12, "When the cubic contents and temperature of the air supply are known, what velocity should be considered when determining the size of the horizontal and vertical pipes

and register outlets in a warm air heating system with outside air supply and when the air is circulated, also the size of these air supply ducts and the velocity in them," was discussed by Messrs. Thompson, Chew and Jones.

Mr. Hale made an announcement of an automobile excursion for the ladies, and then, on motion, the meeting adjourned to 2 P.M.

The President: We will now proceed to Topic No. 13, "The desirability of accumulating data as to the life of wrought iron and steel pipes in steam and hot water heating systems."

The topic was discussed by Messrs. Chew, Weinshank, Gormly, Kerr, May, Morgan and Secretary Mackay.

Topic No. 14, "Chimneys *versus* forced draft, and their relative advantages," was then discussed by Mr. Wing.

Topic No. 15, "The durability of different kinds of nipples for connecting radiator sections relative to the material and the capacity to withstand shocks and strains, also the effect on boiler connections, was discussed by Messrs. Donnelly, James Mackay, Kerr, and McCann.

Mr. McCann: Is it in order to ask a question for information, Mr. President?

The President: Certainly.

Mr. McCann: How would you measure the surface of a radiator; for instance, take a section of wall radiation with a great many ornamental features, how would you correctly measure the surface and be absolutely sure that you had the actual number of square feet?

The question was discussed by Messrs. Hudson, Morgan, Kinealy, McCann, Donnelly and Secretary Mackay.

Secretary Mackay: Before we adjourn I would like to make this motion: That it is the sense of the members present that this meeting has been eminently satisfactory in every way, and that we have accomplished all that we have anticipated or desired.

Mr. Chew: I second the motion.

The President: Gentlemen, you have heard the motion, and I think it would not be out of order to supplement the motion with the statement that we are thankful to those gentlemen who have given us their presence here even though they have said nothing; some of them have encouraged us by their pres-

ence, which shows that the work that we are engaged in is appreciated, and we certainly are thankful to those who are non-members and members who have given us of their knowledge and information and have given us of their time here to make our meeting a success. Gentlemen, you have heard the motion, are you ready for the question?

A Voice: Question.

The President: Those in favor of the motion please signify it by saying "Aye"; those opposed by saying "No."

(Motion carried.)

The Secretary: I move that we adjourn *sine die*. (Seconded.)

(Motion carried and meeting adjourned.)

List of Members and Guests present at the Semi-annual Meeting, July 19 and 20, 1906:

MEMBERS.

Allen, John K.	Galloup, John O.	McCann, Frank G.
Bishop, Chas. R.	Gormly, John.	Morgan, D. F.
Blackmore, J. J.	Graham, Joseph.	Neiler, Samuel G.
Boylston, John.	Graves, W. B.	Osbourn, M. P.
Bradley, Eugene P.	Hale, John F.	Patterson, N. L.
Brennan, John S.	Harvey, Andrew.	Patterson, W. S.
Bronaugh, W. L.	Hoffman, Geo. D.	Pope, Wm. A.
Capron, Edmund F.	Hudson, P. S.	Schaffer, John P.
Chew, Frank K.	Jones, A. O.	Smith, F. W.
Connolly, John A.	Kehm, August.	Snow, Wm. G.
Davidson, W. H. A.	Kerr, Frank E.	Stannard, Jas. H.
Davis, Burt C.	Kinealy, Prof. J. H.	Thompson, R. S.
Davis, Jas. H.	Lewis, Samuel R.	Waters, T. J.
Donnelly, Jas. A.	Mackay, James.	Webster, Warren.
Driscoll, Wm. H.	Mackay, Wm. M.	Widdicombe, R. A.
Edgar, A. C.	Mallory, H. C.	Wing, L. J.

GUESTS.

Ainsworth, A. A.	Brownell, C. D.	Dickerson, Geo. H.
Allen, E. P.	Busche, Wm. C.	Downe, Geo. E.
Andrews, Geo. C.	Butler, L. M.	Dugger, J. P.
Apperson, R. A.	Cameron, A. S.	Ebersole, Morris R.
Armagnac, A. S.	Cameron, W. A.	Ellis, H. W.
Aschaffenburg, A. A.	Conine, H. B.	Fergus, W. H.
Ball, Chas. B.	Cooke, D. I.	Fishwick, E. F.
Barnes, T. S.	Curtis, W. W.	Flint, H. H.
Braatz, T.	Dams, F. W.	Foster, Chas. K.
Brewer, S. S.	Davis, Richard J.	Frantz, W. G.

Gifford, Robt. L.
Gordon, E. M., Jr.
Green, W. C.
Hanly, T. T.
Haraling, J. H.
Henning, F. H.
Hill, Wm. H.
Hoffman, J. W.
Houston, F. K.
Howell, Lloyd.
Howell, S. S.
Hoyt, A. T.
Jewett, T. N.
Kauffman, Benj.
Kilender, A.
Knorr, Henry J.
Kulp, Geo. H.
Larkin, R. W.
Lord, H. I.
May, Edwin I.
Martin, J. H., Jr.
Madden, S. J.
MacNichol, F. F.
McArthur, C. D.
McLelland, H. B.
McIntyre, Melvel B.
Miller, J. J.
Mott, Edw. P.
Murphy, Everett N.
Newport, Chas. F.
Noone, J. A.
Ott, H. J.
Phegley, Frank G.
Pickels, Wm. D.
Rice, Arthur L.
Ryan, E. J.
Schad, A. E.
Schroeder, Carl P.
Schroth, A. H.
Shay, John T.
Scovel, L. A.
Scudder, Wm. M.
Simmons, C. H.
Sisson, C. W.
Stark, E. A.
Stadden, H. V.
Stern, Daniel.
Straw, L. W.
Taylor, Wm. E.
Tjersland, Alfred.
Varney, A. W.
Vlandincroft, T.
Walch, Robt. H.
Warneke, Herman J.
Willard, H. P.
Willis, Ralph P.
Weinshank, Theo.
Woodbury, E. K.
Young, J. B.
Younglove, E. H.

CLXII.

HEAT LOSSES AND HEAT TRANSMISSION.

BY WALTER JONES, STOURBRIDGE, ENGLAND.

(Member of the Society.)

Heat losses and heat transmission, examined critically and constructively, in the hope of arriving at some data and some simple method of calculation for ascertaining what radiator or pipe surface for hot water will be required to give any required temperature in ordinary buildings.

The want of unanimity, and the conflicting tables and formulæ given by various writers on this subject, afford ample evidence that some effort should be made to obtain results with some approach to uniformity.

The subject is extremely difficult. The members of the heating trade are indebted to several writers for the efforts made to solve it, and as frequent references will be made to authors of considerable repute, it is in no carping or critical spirit, but with an earnest desire to ascertain *what* is wrong, not *who* is wrong. We may all be right sometimes, but we are not right always, and the infallible man is not yet born.

When we have to prepare a scheme, or an estimate for warming a building, we must first ascertain what are the heat losses, how, why, and in what proportion these losses occur, and then provide for heat transmission to compensate for the theoretical or actual loss, and thus restore the balance; this would at first appear a very simple matter, but it is not so simple as it looks.

The building may be constructed of brick, timber, stone, concrete, glass, or other materials, or a combination of any or all of these materials. The amount of heat lost will depend largely upon the materials used—glass, wall, wood, iron, etc.—each substance requiring a different factor, coefficient or multiple, and the pipe or radiator through which the heat is transmitted should bear some definite proportion to the materials through which

the losses occur; this coefficient we will call the Surface Ratio (S. R.) or the Surface Required (in superficial feet) of pipe or radiator to provide for the loss per square foot of glass, wall, timber, sheet iron, or other material.

When speaking of the air inside the building, the calculations will be based on *cubic feet* and the Surface Ratio (S. R.) of pipe or radiator will be proportioned to the number of cubic feet of air in the buildings, and the number of times the air requires to be changed per hour.

To avoid confusion, let me explain that we are not at present dealing with the difference in temperature between the inside and the outside of the building; this will require a separate and distinct calculation. We will first consider what fraction of a foot of radiator or pipe surface will transmit the heat necessary to compensate for the loss of 1 degree Fahr. through the glass, wall, or the air contained in the building.

To economize space, and to enable the reader to follow the description, and check the calculation, I give the following:

Abbreviations, and their Definitions.

Co.	Coefficient or multiplier to cover S.R. & T.R. losses.
C.C.	Cubic capacity.
C.F.	Cubic feet.
D.	Difference in temperature.
D.D.	Degree difference in temperature.
D.E.	Decimal equivalent.
F.S.R.	Square feet of radiation.
G.	Glass, square feet.
I.T.	Inside Temperature Fahr.
L.U.	Loss in units by glass, walls, etc.
O.T.	Outside temperature Fahr.
R.	Radiation *surface*, for equivalent *surface* of glass, wall, etc.
Rec.	Reciprocal or Divisor to cover S.R. & T.R. losses.
S.H.	Specific heat.
S.R.	Surface Ratio = square feet of surface of pipe or radiator, per square feet of glass, wall, etc.
T.R.	Temp. Ratio = multiplier to cover the difference in temp. only.
U.	Units British Thermal.
U.T.	Units transmitted by Radiator, per square foot, per degree, per hour.
U.pF.	Units per foot.
U.pF.pD.	Units per foot per degree difference.
U.pF.pH.	Units per foot per hour.
U.pF.pD.pH.	Units per foot per degree difference per hour.
W.	Wall (exposed) square feet.
W.T.	Water temperature (average).

Loss in units per ft. per deg. ÷ Rad. U.pFt.pD = **S**urface **R**atio or sq. ft. of pipe or radiator, per sq. ft. of glass, wall, etc.

$\left.\begin{matrix}\text{G.}\\ \text{W.}\\ \text{C.C.}\end{matrix}\right\}$ x S.R. = **R**adiation Surface (sq. ft.) for equivalent surface of glass, wall, etc.

R. x TR. = **S**quare **F**eet **R**adiation required to cover all losses.

F.S.R. at a given temp. x D.E. = Square feet Rad. for any required temp.

Heat is measured by means of thermometers. The British standard unit is the amount of heat required to raise the temperature of one pound of water at 32 degrees Fahr. 1 degree —*i.e.*, from 32 degrees to 33 degrees Fahr.—the letter U being used as the abbreviation for Unit.

On the continent of Europe, where the Centigrade thermometer is used, the standard of measurement is the Calorie, or the amount of heat required to raise 1 kilogramme (2.204 pounds) of water 1 degree Cent.—1 degree Cent. being equal to 1.8 degree Fahr.—and units may be converted to calories, or calories to units, as follows:

B. T. U. $\times$ .252 = Calories.

Calories $\times$ 3.968 = B. T. Units.

This introduction will appear to many expert engineers to be somewhat elementary, but heating engineers are not all mathematicians, and in making important calculations it is as essential to have a sound basis as it is to have a good foundation when erecting a lofty building. If I commenced by saying that 84 inches = 1 foot, you would think that I was fooling, and yet if we compare the statements made by various authors on the loss in units per square foot of glass, per degree difference per hour, the difference is over 600 per cent. or equivalent to saying that 84 inches = one foot lineal.

The calculations in this paper will refer principally to the losses by glass, by exposed walls, and by the air in the rooms (cubic capacity) and the leakage through the walls, doors or up the chimney or ventilating shaft, as no rule for ascertaining the required amount of heating surface will give satisfactory results unless these three factors are duly considered.

The authorities quoted in Table I. showing the surface losses, or loss of heat from the glass, the walls, and the air in the building (*i.e.*, the cubic capacity) do not give the figures exactly as shown; these have been reduced to one standard for convenience of comparison, so that the discrepancies may be more readily appreciated.

The wide divergence of opinion on the first or elementary basis of providing for a heating installation is not only interesting; in my opinion it is humiliating. Can we wonder that heating engineers often fail to get the results they strive for? The

TABLE I.

Showing the variations in the HEAT LOSSES given by different authors.		Loss in Units per Foot, per Degree, per Hour.		
Authority.	**Page.**	**Glass, Sq. Feet.**	**Wall, Sq. Feet.**	**Capacity. Cubic Feet.**
Box (T.), on "Heat"	222,233 Greenhouse.	.306 .391 .40 .41		
	220 Windows.	.504 .515 .53		
Cox (A.), "Water Circulation"	81 Greenhouse Windows.	1.05 1.57	.157	.020
Keith (J.), "History of Labor"	66	1.125	.225	
Baldwin (W. J.), "Hot Water Heating from Hood."	86, 90, 91	1.53 2.248	.153	
Carpenter (Professor), "Heating and Ventilation"	59, 205, 209	1.	.25	.018
Dye (F. Hood) on "Warming"	239	1.5		
Bennett (G. G.), "Domestic Engineering" Mar., '06	12	.543	.223	.0205
Allen (J. R.), "Heating and Ventilation."		Wall 8″ thick.		
(German)	22	.776	.46	.018
(Carpenter)	23	1.	.25	.018
		Wall 10″ thick.		
Rietschel, Germany	Windows Skylight	1.0865 1 156	.35	.019
Hauss (C. F.), Antwerp	Windows Skylight	1. 1.06	.34	.019
		Wall 9″ thick.		
Wallas (J. C.), London		1.09	.47	
Jones (Walter), "Rule D,"	8	1.28	.428	0.25
Allowing over Prof. Rietschel's for factor of safety		16%	22%	35%
The reason for this is given on page 240.				
Difference between the highest and the lowest		= 634%	213%	80%

Mr. Allen	gives	2	ft.	super.	of	wall	As equivalent to 1 ft. super. of glass, showing a difference of 400%.
Mr. Bennett	"	2½	"	"	"	"	
Prof. Rietschel	"	3	"	"	"	"	
Prof. Carpenter	"	4	"	"	"	"	
Mr. Keith	"	5	"	"	"	"	
Mr. Baldwin	"	10	"	"	"	"	

marvel is that they are ever successful. One of the first and most important problems for heating engineers to decide is an approach to uniformity, by adopting some definite data as to the actual surface losses by glass, wall, etc., and the actual heat transmission from the pipe or radiator, that will provide for the surface losses of glass, wall, or other material.

Now, so far as I have been able to ascertain, the tables by Professor Rietschel, of Germany, and of Chas. F. Hauss, Antwerp, Belgium, compiled after many exhaustive tests, appear to be the most reliable yet published, and these are converted from the metric or calories per square meter, into B. T. Units per square foot, for convenience of reference.

TABLE 2.

LOSS IN B. T. U. PER SQUARE FOOT PER DEGREE DIFFERENCE PER HOUR.

	Rietschel.	Hauss.
Glass surface (single) per square foot	1.0865	1.0
" double glazed	.47	.46
Skylights single	1.156	1.06
" double glazed	.48	.48
Thick.		
Walls (outside) 4½ inches	.49	.48
" " 10 "	.35	.34
" " 15 "	.27	.26
" " 20 "	.22	.22
" " 25 "	.18	.18
" " 30 "	.15	.16
" " 35 "	.13	.13
" " 40 "	.12	.12
Air, one change per hour per cubic foot	.019	.019
" two changes = .019 × 2 =	.038	.038
" three " = .019 × 3 =	.057	.057

Suppose we adopt Professor Rietschel's coefficient for heat losses; and the heat transmission from radiators as 1.8 units per square foot per degree difference, per hour, which from a single column radiator or plain pipe will be found fairly accurate, we then proceed to find the fractional part of a square foot of radiator that will make good the various losses as under:

TABLE 3.

	1	2	3
	Loss in Units per F. per D. per hour.	Units transmitted by Radiator per F. per D. per hour.	Surface ratio of pipe.
Glass in windows	1.08 ÷	1.8 =	.6 per sq. ft. of glass.
Wall 10″ thick	.35 ÷	1.8 =	.2 per foot of wall.
Air cubic capacity	.019 ÷	1.8 =	.01 per cubic foot for one change per hour.
" " " 2 changes.	.038 ÷	1.8 =	.02 two changes per hour.
" " " 3 "	.057 ÷	1.8 =	.03 three changes per hour.

Formula 1. L. U. ÷ U. T. = S. R. (Surface Ratio of pipe or Radiator.)

Formula 2. G. (square feet × S. R. = R. (Rad. Surface.)

Example 1.

S. R.

Any given surface of Glass × .6 = R. (Radiation *surface*) for given *surface* of glass.

" " " " Wall × .2 = R. (Radiation *surface*) for given surface of wall.

" " Cubic contents × .01 = R. (Radiation *surface*) for one change of air.

Let me repeat that up to the present we have been considering the relative heat losses, and heat transmissions due to *surface* only, from which we find that one foot of glass will require 0.6 square feet of pipe surface for *each degree* difference in temperature.

We will now consider the second equation, which deals with the losses due to the DIFFERENCE in TEMPERATURE, as the manner in which these two equations have been mixed is most confusing; some of the authorities quoted in Table I. (page 236) apparently assume that the glass loses the same amount of heat per square foot as the radiator transmits per square foot, whereas the relative proportion is as 108 is to 180, or a difference of 66 per cent. Take the following sentence: "The room is to be kept at 70 degrees, then the steam pipe 228 degrees — 70 degrees = 158 degrees difference in temperature; *each square foot of heating surface will give to the air in the room* 158 *heat units,"* whereas it should read, each square foot of heating surface will transmit 158 degrees × 1.8 degrees = 284 heat units.

So far as I can understand the calculations of G. G. Bennett, as shown in Table I., appear to have been taken on this erroneous basis.

DIFFERENCE IN TEMPERATURE.

The method adopted by all authorities appears to be practically the same, viz.:

Formula 3. $\frac{\text{I.T.} - \text{O.T.}}{\text{W.T.} - \text{I.T.}} = \text{T.R.}$ Multiplier to cover losses due to difference in temperature only.

Example 2. For 70° inside, 0° outside, and water 170°.

$$\frac{70 - 0}{170 - 70} = \frac{70}{100} = .7 \text{ (T.R.)}$$

or Multiplier to cover losses due to difference in temperature.

This appears to be a reasonable and scientific method, *providing the losses for each degree difference in temperature* are *the same at all temperatures,* whether the difference is one degree only, or 100 degrees, but I hope to show that the losses do not bear the same relative proportions under the extreme conditions mentioned.

I find that in the tables prepared by Professor Rietschel, C. F. Hauss, J. H. Mills and others, the coefficients or multiples for differences in temperature of 50 degrees, 60 degrees or 70 degrees are 50, 60 or 70 times the coefficient given for 1 degree only, which appears to me to be erroneous, and will be referred to later.

I described (Formula 1, page 237) the method for ascertaining the S. R. (Surface Ratio); in Formula 2, page 237, the method for obtaining R. (Radiator Surface) for a given surface of glass, etc., and in Formula 3, page 238, the method for obtaining T. R. to cover the losses due to the difference in temperature.

I will now give Formulas 4 to 8, showing how the necessary calculations may be completed.

Given the L. U. (Loss in Units) to find the Coefficient (or Multiplier) or the Rec. (Reciprocal or Divisor) to cover the S. R. and T. R. losses.

Formula 4. $\frac{\text{L. U.} \times \text{T. R.}}{\text{U. T.}} = \text{Co.}$ (Multiplier to cover S. R. and T. R. losses.)

Formula 5. The unit $1 \div \text{Co.} = \text{Rec.}$ (Divisor to cover S. R. and T. R. losses.)

Given the Co. (Multiplier), to find the L. U.

Formula 6. $\frac{\text{Co.} \times \text{U. T.}}{\text{T. R.}} = \text{L. U.}$ (Loss in units.)

Given the Rec. (Divisor) to find the L. U.

Formula 7. $\frac{1 \times \text{U. T.}}{\text{Rec.} \times \text{T. R.}} = \text{L. U.}$ (Loss in units.)

Formula 8. Or the unit $1 \div \text{Rec.} = \text{Co.} \div \text{T. R.} = \text{S. R.} \times \text{U. T.} = \text{L.U.}$

Some examples of the use of these formulas are given in Table 4, page 240.

Example of Formulas 7 and 8:

If 2.57 is the Rec. (Divisor) for glass, what would be the L. U.?

$$\frac{\overset{\text{Unit.}}{1} \times \overset{\text{U. T.}}{1.8}}{\underset{\text{Rec.}}{2.57} \times \underset{\text{T. R.}}{.7}} = \frac{1.80}{1.79} = 1. \text{ (loss in units per F. per D. per hour.)}$$

The following Co. (Multiplier) and Rec. (Divisors) are calculated from Formulas No. 4 to 8 (page 239), using T. R. as Exam. 2 (page 238).

TABLE 4.

1.	2. L. U.	3. U. T.	4. S. R.	5. T. R.	6. Co.	7.	8. Rec.	9.
Cox.								
Glass	1.57	÷ 1.8 =	.87	× .7 =	.609	& $\frac{1}{.609}$ =	1.64	for Glass.
Wall	.157	÷ 1.8 =	.087	× .7 =	.0609	& $\frac{1}{.0609}$ =	16.4	for Wall.
C.C.	.020	÷ 1.8 =	.0114	× .7 =	.00798	& $\frac{1}{.00798}$ =	125.	for C. C.
Carpenter								
G.	1.	÷ 1.8 =	.555	× .7 =	.3885	=	2.57	" G.
W.	.25	÷ 1.8 =	.14	× .7 =	.098	=	10.	" W.
C.C.	.018	÷ 1.8 =	.01	× .7 =	.007	=	142.	" C. C.
G. G. Bennett assumes that Rad. transmits 1 U. per F. per D. per H instead of 1.8 Units as taken by other authorities.								
G.	.543	÷ 1 =	.543	× .7 =	.38	=	2.63	" G.
W.	.223	÷ 1 =	.223	× .7 =	.156	=	6.4	" W.
C.C.	.0205	÷ 1 =	.0205	× .7 =	.01435	=	70.	" C. C.
Rietschel								
G.	1.085	÷ 1.8 =	.6	× .7 =	.42	=	2.38	" G.
W.	.35	÷ 1.8 =	.2	× .7 =	.14	=	7.4	" W.
C.C.	.019	÷ 1.8 =	.01	× .7 =	.007	=	142.	" C. C.
Hauss, C. F.								
G.	1.	÷ 1.8 =	.555	× .7 =	.3885	=	2.57	" G.
W.	.34	÷ 1.8 =	.19	× .7 =	.133	=	7.5	" W.
C.C.	.019	÷ 1.8 =	.01	× .7 =	.007	=	142.	" C. C.
W. Jones								
G.*	1.28	÷ 1.8 =	.71	× .7 =	.497	=	2.	* " G.
W.*	.428	÷ 1.8 =	.238	× .7 =	.166	=	6.	* " W.
C.C.*	.025	÷ 1.8 =	.014	× .7 =	.01	=	100.	* " C. C.

*In the above formulas, as on page 237, and in Rule D, below, I have added to the L. U. given by Professor Rietschel 16% for Glass, 22 % for Wall, and 35% for air, and I do not think this will be any too much.

Some engineers add 5, 10, 20, up to 100% to their calculations as a factor of safety, which ought not to be necessary. I have seen it stated that the loss through walls and windows is equal to three changes of air per hour without any other provision for ventilation, and although this may be an exaggeration, the loss is much greater than is generally supposed.

I have met with hundreds of cases where the guaranteed temperature could not be obtained, until from 50% to 100% of radiation had been added, and I strongly advocate the putting in of sufficient radiation to obtain the results easily, and if this can be done with water at 165° instead of 170°, no one will have cause for complaint.

RULE D.

For Ordinary Buildings (Not Horticultural).

To obtain 70 degrees inside when 0 degrees outside, with water 170 degrees.

$$\left.\begin{array}{lr} \text{Glass (Sq. ft.)} & \div\ 2 \\ \text{Wall (Sq. ft. exposed)} & \div\ 6 \\ \text{Cubic Capacity (In Feet)} & \div\ 90 \end{array}\right\} = \text{Square feet of Radiation for rooms under 5,000 Cubic Feet.}$$

As the rooms increase in size the proportion of glass and wall to the Cubic Capacity is relatively smaller, the walls are thicker and the losses are proportionately less.

To provide for this, the Divisors for all the glass and for exposed walls may be taken as constants, but the Divisor for C. C. will require some elasticity; the exact Divisor can only be deter-

mined by results obtained from actual tests, but I estimate they would be approximately as follows:

Cubic Capacity	÷ 90	for rooms under	5,000	Cubic Feet.
" "	÷ 100	" "	5,000 to 25,000	" "
" "	÷ 110	" "	25,000 to 50,000	" "
" "	÷ 120	" "	50,000 to 100,000	" "
" "	÷ 130	" "	100,000 and upwards	" "

The above rule is simple, it is short and quick, and will, I think, be found more reliable than many of the complicated formulas that are published; it will tend to reduce the number of errors by miscalculation, and should it be found necessary to make any modifications this can readily be done from the formulas already given.

Some objection may be taken to Rule D because the ceilings or roof are not taken into consideration, but the allowances made and described at the foot of Table 1, and following Table 4, will, I think, provide for this, and I have used a similar rule for British conditions for several years with very satisfactory results.

Comparisons of formulas to ascertain at one calculation the radiation required to give 70 degrees inside when 0 degrees out, and water 170 degrees, in a room with 40 feet glass, 600 feet wall and 4,000 cubic feet.

TABLE 5.

1.	2.	3.		4. *Rec.	5.	6.
A. Cox	Glass	40 Ft.	÷	1.64	= 24	92 Sq. ft. Rad.
	Wall	600	÷	16.4	= 36	
	C. C.	4,000	÷	125.	= 32	
Professor Carpenter	Glass	40 Ft.	÷	2.6	= 15	103 Sq. ft. Rad.
	Wall	600	÷	10.	= 60	
	C. C.	4,000	÷	140.	= 28	
G. G. Bennett	Glass	40 Ft.	÷	2.63	= 15	165 Sq. ft. Rad.
	Wall	600	÷	6.4	= 93	
	C. C.	4,000	÷	70.	= 57	
Professor Rietschel	Glass	40 Ft.	÷	2.38	= 16	128 Sq. ft. Rad.
	Wall	600	÷	7.14	= 84	
	C. C.	4,000	÷	142.	= 28	
Hauss, C. F.	Glass	40 Ft.	÷	2.57	= 15	123 Sq. ft. Rad.
	Wall	600	÷	7.5	= 87	
	C. C.	4,000	÷	142.	= 28	
W. Jones. Rule D	Glass	40 Ft.	÷	2.	= 20	164 Sq. ft. Rad.
	Wall	600	÷	6.	= 100	
	C. C.	4,000	÷	90.	= 44	

The results obtained in Table 5 show variations of 76% for one, and the same room, which can scarcely be considered satisfactory.

*** The Multipliers (Co.) in col. 6, Table 4, may be used instead of the Divisors (Rec.) given in col. 8. The result will be the same.**

I think the discrepancies already referred to prove that our formulas need some revision if we are to obtain satisfactory results.

Speaking of churches, an English author says: "It is not necessary to calculate on a greater interior height than 16 feet; a 2-inch pipe carried along each side, or around the church about 16 feet above the floor level, deals with the upper strata of air," whereas Mr. C. F. Hauss says:

Add	$3\frac{1}{3}$ %	where the height of room exceeds 13 feet.
	$6\frac{2}{3}$ %	" " " " " " 15 "
	10 %	" " " " " " 18 "

I would simply ask, "When experts differ who is to decide?" So far as my own personal experience goes, I should calculate the whole Cubic Capacity, and I should not add either 3 per cent. or 10 per cent. simply because of the height of the room.

When a stated temperature is required, 30 degrees to 60 degrees as in England, or 0 degrees to 70 degrees as in America, we certainly ought to get within 10 per cent. of the surface required, whatever formula is used, but in extreme cases, where unusual temperatures are demanded, such as 90 degrees to 100 degrees, a variation of 20 per cent. may be excusable; at present, a difference of from 100 per cent. to 200 per cent. is not at all uncommon.

I have puzzled over this problem for many years, and have brought the matter before the British Institute of Heating and Ventilating Engineers, but it is still, so far as I know, an unsolved problem.

All the tables prepared by Professors Carpenter, Rietschel, Hauss, Mills and others, that have come under my notice, assume that the T. R. losses are practically the same at all temperatures; the losses for a difference in temperature of 70 degrees are given as 70 times the loss for 1 degree.

If a radiator transmits 1.8 units per square foot for 1 degree difference in temperature, does it transmit 180 units for 100 degrees difference in temperature?

If glass loses 1 unit per foot for 1 degree difference, does it lose 100 units for 100 degrees difference? I think the loss is greater under the latter conditions.

If a wall loses .35 units per foot for 1 degree difference, does it lose 35 units for 100 degrees difference?

I think it loses much more. If not, how are we to account for the enormous increase of surface (proportionately) to obtain the higher temperatures?

I stated on page 6 that the basis of our calculations was at fault somewhere, and in my opinion the only way in which this problem can be solved will be by a large number of actual tests, in rooms having considerable variations in size, materials of construction and covering a wide range of temperatures, the results being carefully plotted on a diagram, and some simple rules formulated from the results thus obtained.

In my experience as a heating engineer I am frequently asked for extreme temperatures to meet some special requirement, and have not yet met with reliable data for the purpose. I have in many cases had to formulate my own data from experiments. Here is an example that is rather exceptional. A client wishes to know if I can supply a hot-water plant that will keep wax in a liquid state at 400 degrees Fahr. I have promised to do it. Do you know of any printed formula for such a problem as this? I don't.

Let me give two ordinary examples, and I shall be glad if some of the members of our Society will work out by any published rule or formula what surface they consider necessary to give the stated temperatures before referring to the answer given to your secretary, and I think they will be surprised at the result. It will be more interesting and profitable than any guessing competition.

Example No. 3 relates to a room on the first floor, about 70 feet long by 32 feet wide, plastered ceiling reaching half way up the slate roof, and the four walls outer, or exposed.

The rooms underneath were warmed to 60 degrees, so there would be no appreciable loss through the floors. The exposures were:

Glass (half windows, and half skylight)	370 square feet.
Walls exposed (four sides of room)	1,530 " "
Ceiling, lath and plaster	2,130 " "
Cubic capacity (ventilators and windows closed)	23,500 cubic feet.

Test 18. Water temperature (average) was 161 degrees. Inside temperature 76 degrees, and outside 30 degrees Fahr.

Test 19. Water temperature (average) was 161 degrees. Inside temperature 87 degrees, and outside 42 degrees Fahr.

Test 20. Water temperature (average) was 157 degrees. Inside temperature 96 degrees, and outside 48 degrees Fahr.

Six rows of 3-inch pipes, one above another, were used wholly or partially during tests. How many square feet were required respectively for Tests 18, 19 and 20?

Example No. 4 was a room on the ground floor for drying timber or lumber, a room above was kept at 60 degrees, and the floor above was laid with tongued and grooved 1⅛-inch boards, the ceiling under the joists being matchboarded.

Glass in windows..........	50 square feet.
Walls exposed......................	470 " "
Matchboard ceiling....................................	700 " "
Cubic capacity (ventilators closed).............	4,850 cubic feet.

Test No. 22. Water temperature (average) 180 degrees. Inside temperature 100 degrees, outside 40 degrees Fahr. Four-inch pipes were distributed over the floor 6 inches from the floor level. How many square feet of Radiation were required to obtain the results given in Test *22*?

The tests were carefully taken for several days, and the figures given to your secretary may be accepted as reliable.

I shall be glad to hear what the American Heating Engineers make of this, and will simply state that engineers of considerable repute in Great Britain, Germany and Hungary did not get within 100 per cent. of the actual surface required, which shows that the usual formulas need some revision.

I will now endeavor to point out what appears to me to be the chief cause of the discrepancies to which I have referred, and will ask you to study carefully Tables 6 and 7.

The temperature ratios (T. R.) are calculated as follows, and are tabulated for convenience of reference:

I. T. O. T.

$$\frac{60-30}{170-60}=\frac{30}{110}-.272$$ (Temperature Ratio) for 60° Inside, 30° Outside, and Water 170°.

W. T. I. T.

TABLE 6.

TEMPERATURE RATIOS, OR MULTIPLIERS TO COVER LOSSES DUE TO THE DIFFERENCE IN TEMPERATURE ONLY.

Inside Temp.	Outside Temperatures, and Water 170° Fahr.										
	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°
40°	.307	.269	.230	.192	.153	.115	.077	.038	—	—	—
45°	.36	.32	.28	.24	.20	.16	.12	.08	.04	—	—
50°	.416	.375	.333	.291	.25	.208	.166	.125	.083	.041	—
55°	.478	.434	.391	.347	.304	.260	.217	.173	.130	.087	.043
60°	.541	.5	.454	.409	.363	.318	**.272**	.227	.181	.136	.090
65°	.619	.571	.523	.476	.427	.381	.333	.276	.238	.190	.142
70°	.7	.65	.6	.55	.5	.45	.4	.35	.3	.25	.2
75°	.789	.736	.684	.631	.579	.526	.473	.421	.368	.315	.263
80°	.888	.833	.777	.722	.666	.611	.555	.5	.444	.288	.333
85°	1.	.941	.882	.823	.764	.705	.647	.588	.529	.470	.411
90°	1.125	1.06	1.	.937	.875	.812	.75	.687	.625	.562	.5
100°	1.428	1.357	1.285	1.214	1.142	1.07	1.	.928	.857	.785	.714

NOTE.—The **T. R. ·272**, under the Water Temperature 170°, Inside Temperature 60°, and Outside 30°, will be frequently referred to as **UNITY**, these temperatures being adopted as a moderately fair basis for the English climate.

Please notice the summary of the *percentage* of *increase* in the temperature ratios above, as shown in Table 7.

TABLE 7.

FOR ORDINARY BUILDINGS, ROOMS UNDER 4,000 CUBIC FEET THE APPROXIMATE RADIATION TO GIVE.

1. Outside.	2. Inside.	3. Sq. feet radiation per 1000 C. feet.	4. Diff. in temperature.	5. Sq. feet radiation.
From 30° to	60° requires	15 +	30°	= .5 per Deg. diff.
" 30° "	70° "	23 +	40°	= .57 "
" 30° "	80° "	38 +	50°	= .76 "
" 30° "	90° "	65 +	60°	=1.08 "
" 30° "	100° "	112 +	70°	=1.6 "
Total increase per cent.	66%	646%	133%	=220% "

FOR GREENHOUSES UNDER 4,000 CUBIC FEET THE APPROXIMATE RADIATION REQUIRED TO GIVE.

				F. S. R.
From 30° to	60° requires	65 +	30°	=2. per Deg. diff.
" 30° "	70° "	95 +	40°	=2.37 "
" 30° "	80° "	130 +	50°	=2.60 "
" 30° "	90° "	178 +	60°	=2.96 "
" 30° "	100° "	238 +	70°	=3.4 "
Total increase per cent.	66%	266%	133%	=70% "

SUMMARY OF THE TEMPERATURE RATIOS SHOWN IN TABLE 6 WITH WATER 170°.

		T. R.		F. S. R.
From 30° to	60° requires	.272 +	30°	= .00906 "
" 30° "	70° "	.4 +	40°	= .010 "
" 30° "	80° "	.555 +	50°	= .011 "
" 30° "	90° "	.75 +	60°	= .0125 "
" 30° "	100° "	1.0 +	70°	= .01428 "
Total increase per cent.	66%	267%	133%	=57.6% "

I wish to call special attention to this table, because although the figures are approximate only, and would be liable to some variation according to the size of the rooms and the materials used in construction, it gives a clear indication why the radiation provided to cover the T. R. losses is altogether inadequate.

In Col. 3, the F. S. R. increase provided is 57.6 per cent. only, against 646 per cent. for the Radiation required.

In Col. 5, the F. S. R. increase provided is 57.6 per cent. only, against 220 per cent. for the Radiation required.

I do not give these figures as absolutely correct, although I believe they are not far wrong; I do not suggest that this enormous difference is all due to the *Temperature Ratio* losses; the *surface* losses probably vary with the extreme differences in temperature—*i.e.,* the surface value of one foot of radiation may not bear the same relative proportion to one foot of glass, or wall, when 80 degrees difference in temperature, as it would when 5 degrees difference only.

Whether this opinion be correct or not, I am strongly of the opinion that it will be better to accept the surface losses as constant at all temperatures, and give whatever elasticity is necessary to the Temperature Ratios, otherwise the factors or calculations will lead to endless confusion.

The point I wish to emphasize is that it would be extremely inconvenient to be compelled to use a different factor for each substance, and for every degree (or for every 5 degrees) difference in temperature, either in the building or in the water, whereas it would be a great convenience and much simpler to use two factors as constants, such as a divisor of 2 for glass, and 6 for wall; and an elastic divisor for the Cubic Capacity that would compensate for the varying thickness of the walls, and for the larger volume of air (proportionately) to the wall or other cooling surfaces; the result thus obtained for stated temperatures, such as 70 degrees inside, 0 degrees outside, and water 170 degrees to be called Unity. Another table of factors, called D. E. (Decimal Equivalents), could then be formulated to cover a wide range of temperatures, inside or outside of the building. I have given much thought and study to this subject, and can think of no better plan, but if any of our members can suggest a simpler or better method I shall give it my careful consideration and hearty support.

When I commenced this paper it was my intention to give a diagram showing the approximate actual losses, as against the theoretical T. R. losses, and a Table of Dec. Equivalents with Multipliers to obtain the Radiation required for various temperatures, but the paper is already sufficiently long, and I have no data from actual tests with zero temperatures available to do this with approximately accurate results.

If one of the American members of our Society will take up this subject and communicate with me, I will send him the diagram already prepared, so that he may put it to the test. It will mean some time and trouble, but the results will more than justify it.

DISCUSSION.

Mr. Kinealy: In Table I., page 236, I notice that the author, Professor Allen, is saying that the loss in units per foot, per degree, per hour, given in column No. 3, is .776 for a wall 8 inches thick. That is supposed to be taken from some German author. If Professor Allen is here I should like to have him say whether or not that is the proper and correct quotation, or whether it is a mistake. Then on page 239, in the first paragraph, the author says, beginning with the line at top of the page, "I find that in the tables prepared by Professor Rietschel, C. F. Hauss, J. H. Mills, and others, the coefficients for differences in temperature of 50, 60, or 70 degrees are 50, 60, or 70 times the coefficient given for one degree only, which appears to me to be erroneous and will be referred to later." In reading these authors, I think that the author has failed to bear in mind that Professor Rietschel, Mr. Hauss, and Mr. Mills, when making the statement which he ascribed to them, really meant that that was for average conditions, when the difference between inside and outside is in the neighborhood of 70 degrees. None of these men would for an instant say that the loss for a difference in temperature of 1 degree was only 1-70th of the loss for a difference in temperature 70 degrees, but in order to make the calculation of the engineer simple, they state that where the difference between inside and outside temperature is in the neighborhood of 70 degrees, the loss per degree difference is so much. That is all that they say. Professor Rietschel—I am very familiar with his writings—very carefully points out that where there

is a difference in temperature inside and outside that is great the heat loss is greater than where the difference is small, but for ordinary conditions he said we may assume that the loss per degree is so much. I find the paper exceedingly interesting. I have not attempted to work out any of the problems that the author has given us. But in ordinary work we cannot go into small differences which undoubtedly exist, but which do not affect our work because we cannot take them into account. For instance, suppose we have a room in which we are going to put 40 square feet of surface. It is useless to talk about adding three per cent. to that, because we have not calculated out 40 square feet within three per cent. One per cent. of 40 would be 4-10ths of a square foot; 3 would be 12-10ths or 1 ¼ feet. We would not insist on having it nearer than that. So that many of the points which the author presents we may, I think, well afford to ignore in our work.

Mr. Thompson: I presume the point made just now is correct as to most authorities, but I believe the authorities have led a great many of us astray, because the understanding of it has been that it means exactly what it says in the tables, that is in regard to radiation per degree difference. It ought to take just twice as much heat to heat to 70 when the thermometer outside is zero as it does when the thermometer outside is 35, but I know, and you do too, that it takes more than twice as much; the ratio is not the same by a great deal. I had a pretty good chance to get at that fact by testing things in the use of natural gas, where you can tell exactly the amount of heat you are using, and I found that at zero it takes a great deal more than twice as much than it does at 35 degrees; such tables are confusing. It seems to me there is a scientific explanation to that fact, loss of heat from a building is due to two causes, one is radiation and the other loss is caused by the abstraction of heat by the air in contact with the outside of the building. Now, by increasing the difference in temperature you will produce a current of air on the outside of the building which will more rapidly abstract the heat; the friction will not overcome it all. The higher the temperature of the heating surface the more rapid will be that movement of the air against the wall; everybody is familiar with the fact that it takes a great deal more heat to maintain the temperature in the room when there is wind blowing against it than it does

on a still day, because the wind is constantly removing the heated air from the surface of the wall and furnishing cold air to abstract the heat. You take a room with a large difference between the inside and outside temperatures and you create an upward wind all the time, and I think that increases just about the square of the difference in temperature. I caught myself on that thing one time. I was called on to get up a set of gas burners for a drying kiln, and I worked it out on this line and figured it up, and I fell down about a half; I thought I had gas capacity sufficient to heat the drying kiln, but I didn't have quite half enough, I had to double it. I figured it out on the ordinary basis of 70 degrees temperature, and it worked all right up to 70, but when it got up to 100 it did not work so well, and when it got up to 200 I was stuck, and he wanted it about 400—he wanted 300 anyway, and I had to double it up to get 300. Another thing that makes a large difference is the matter of leakage; it is a more important matter than we sometimes consider. The leakage of air into a room and out of the room depends very much on the difference in temperature between the room and the outside. You take a room where the temperature of the air inside and outside is practically the same, and there will be scarcely any movement of air from the inside to the outside, and from outside to inside, but just as soon as you begin to change the temperature you then cause a leakage of air, *in* at the lower part of the room and *out* at the upper part, and the average constructed building is a long ways from being hermetically tight. The amount of leakage that goes out through the plastered walls is enormous. You increase the temperature and you increase the intake of cold air by leakage, and the outlet of heated air by leakage. Those are problems that we have not, so far as I am able to ascertain, any statistics to deal with.

Mr. Donnelly: There is one other point I want to bring up, and that is this, perhaps it is more noticeable here than in England, and that is whether or not we have lower temperatures or higher temperatures at the time of high wind velocities. We may get a temperature in New York of 10 or 20 degrees above zero, with apparently little wind velocity. There are other occasions when low temperatures are accompanied by very high wind velocities, and in my opinion the leakage of air into the

windward side of the building as well as the conduction of heat from the building is then increased to a very great extent. Unless we know the velocity of the wind and the wind pressure due to that velocity upon the windward side, it is very difficult, well nigh impossible, to tell what the air leakage into the building and the loss of heat from the building at that time would be.

Mr. Lewis: I would like to ask if the other members agree with me in this, that in proportioning the amount of radiation to be used in heating a room, whether the cubic contents of that room has anything to do with the amount of radiation required? It seems to me that we call the losses through leakage and open doors and through the floors—and from the ceiling or through the ceiling—we call that cubic capacity, but the still air irrespective of the amount required for ventilation has nothing to do with the amount of radiation necessary to supply the losses. That is not particularly appropriate for this paper, but in general he speaks as to the contents of the room; it seems to me the contents have nothing to do with it.

Mr. James Mackay: I think that the point Mr. Jones makes is very well taken. That is the much greater amount of radiation required to raise the temperature of a given room higher than the average temperatures. Mr. Thompson speaks of a dry kiln in which it was required to raise the temperature from 300 to 400 degrees, and he found it necessary to double the radiation. Now has anyone any data as to the ratio of increase in radiation that is necessary to raise the temperature of a given room, say, 10 degrees? The ratios given in text-books are almost a fixed quantity. Are they not erroneous, and should we not increase much more than we usually figure? I have found that increasing the heating surface 25 per cent. barely raised the temperature 10 degrees. Now, if instead of heating from 70 to 80 degrees we were heating from 80 to 90 degrees the ratio would increase much more rapidly, and I was wondering if some one had any data on the subject.

Mr. Lewis: Mr. Jones thinks that there is great room for revision of data. I have always found that when we were required to raise the temperature of a room 10 or 20 degrees above our regular common practice it was necessary to increase the radiating surface much more than the average rule calls for.

Secretary Mackay: There is a good deal in this paper that a

person cannot give an immediate answer on. It seems to me that in addition to what is said on the subject at this time it would be well if some members would take the time to verify or change these figures and put in a written discussion, or a paper, in time to be embodied in our proceedings. And in connection with higher temperatures than 70 degrees, I have had occasion at times for different purposes, for operating rooms in hospitals, and drying rooms and work of that kind, to raise the temperature above 70 degrees. I have found that it takes approximately 50 per cent. of the radiation of the room to raise the temperature 10 degrees; I have varied from 70 to 80 and 90 and up to 110 degrees, and I have had good success. Whether I could have done with less radiation, I do not know, but I have accomplished what I set out to do by adding 50 per cent. of the radiation required for 70 degrees, for each 10 degrees.

Mr. Lewis: I think it would be very interesting for all if some of us would agree to figure up the problems Mr. Jones has asked for and possibly tell what the answers are. I would be willing to be one of four or five to do this. Our answers might not be correct, I might be 100 per cent. off, but it would be very interesting if we would do it.

Mr. Widdicombe: By different methods I got at such discordant figures that I bought Mr. Jones's Book on Hot Water Heating to check the results. With coefficients from Mr. Wolff's, Carpenter's and Allen's formulas, I got the following results:

Answer No. 18	Correct.
" " 19	"
" " 20	10% out.
" " 4	100% "

There seems to be a necessity for some experimental data to base rational formulas upon for extreme temperature variations. The only man who seems to have recognized and done this is Mr. Jones. The reason for such a discrepancy is due to the fact that the coefficient for the high and low points is not correct. This will especially apply to hot water.

Mr. Walter Jones (author's reply, added since the meeting): I wish to thank Professor Kinealy for his courtesy in reading my paper. The criticisms on the whole were mild—I hoped and expected that they would have been more caustic.

I beg to reply to the criticisms as follows:

Professor Kinealy, Table I., page 236, was taken from Professor Allen's book (*Heating and Ventilation*), page 22, Table 4, and if the figures therein given of .776 B. T. U. losses for glass are taken, as stated, "from the constants determined by the German Government," I think, with Mr. Kinealy, "that it is either a misquotation" or a printer's error, as I believe the German Government adopts Professor Rietschel's figures of 1.0865 B. T. U. for glass.

Table I., page 239: "The coefficients adopted by Professor Rietschel and others for 70 degrees difference in temperature are 70 times the coefficient for 1 degree difference." Mr. Kinealy said "this applied to average conditions." I think any temperature from zero to 70 degrees would be considered average conditions, but 80 degrees to 100 degrees would be exceptional.

He also says, "None of these men would contend that the loss for a difference in temperature of 1 degree was only 1-70th the loss for a difference of 70 degrees." All the translations I have seen, and I have several from British and German Engineers, show the same loss for each degree difference from zero to 70 degrees—*i.e.,* all up to 70 degrees are multiples of 1 degree—and Mr. Kinealy himself confirms it in the following words:

"To make the calculations of the engineers simple, that is what they state, that where the difference between inside and outside is 70 degrees or thereabouts, the loss per degree difference in that case is so much."

He states that "Professor Rietschel points out that where the difference in temperature is *great,* the heat loss is *greater* than where the difference is *small.*" That confirms the point raised in my paper, which is usually ignored by most Heating Engineers—the terms *great* and *small* are very vague and elastic.

Mr. Box in his excellent book on "Heat," Table 105, page 229, says, "The *ratio of loss* varies from .94 (when the difference in temperature of the air and the body in contact is 18 degrees) to 1.72 (when the difference in temperature is 234 degrees)," or 83 per cent. greater loss under the latter conditions, and I feel sure that not one heating engineer in a hundred allows for the changed conditions here mentioned.

Mr. Kinealy says, "In ordinary work we cannot go into *small*

differences of 3 per cent., etc." I stated in paragraph 4, page 242, that "we ought to get within 10 per cent.," and the difference of 76 per cent. (as shown in Table 5, page 241) for one and the same room, for the *ordinary* temperature of 70 degrees, can scarcely be called "a *small* difference."

I have met with scores of cases where the radiation calculated from recognized formulas has had to be supplemented by additions of 50 or 60 per cent. before the required temperature could be obtained, whereas for exceptional temperatures (90 degrees or 100 degrees) I have found discrepancies of 100 per cent. to 200 per cent. to be quite common. Such discrepancies are not *small,* they are humiliating to engineers who call themselves experts in their craft.

Mr. Thompson says, "It ought to take just twice as much to get 70 degrees inside when zero outside as it does to get 70 degrees inside when 35 degrees outside, but it *takes more than twice* as much." Is Mr. Thompson correctly reported? If so, I think he is mistaken.

I have never had the opportunity of testing with zero temperatures, but I estimate that the ratio, or the proportion of radiation required for the various temperatures would be approximately as follows:

Taking the radiation to give from 0° to 70° as 1. (Unity.)
The radiation to give from 35° to 70° would be .63.
" " " " 0° " 35° " .37.

Assuming the water temperature to be 170 degrees, the proportions would thus be 37 square feet to give 0 degrees to 35 degrees; 63 square feet to give from 35 degrees to 70 degrees, and 100 square feet to give from 0 degrees to 70 degrees.

Mr. Donnelly missed the point in my paper, or possibly I failed to make my point clear; there is no doubt that wind velocities do exercise an enormous influence, but my point was that under equal *normal* conditions the radiation required for every 5 degrees increase of temperature require to be increased in a much greater ratio as the temperatures inside are increased, and as summarized in Table VII., page 245.

Mr. Lewis, the cubic contents or the air inside the room do certainly affect the calculations, and must be considered in any estimate of the heat losses. The Germans and the Hungarians figure all losses, glass, walls, ceiling, floors, etc., and have co-

efficients for the various materials used in construction, the thickness of the walls, timber, the cubic capacity and the changes of air per hour, and prepare their estimates in a most scientific manner, and even then, when the temperatures are exceptionally high (90 degrees to 100 degrees) they get very wide of the mark.

Mr. James Mackay appears to have struck the right note and interpreted my meaning when he said "Mr. Jones's point is that a much greater amount of radiation than is commonly supposed is required to raise the temperature beyond the average temperatures that we deal with." He asks "if any one has any data for temperatures of 300 degrees?" I would refer him to my book, "Heating by Hot Water," Table I., page 16, for high pressure $\frac{7}{8}$-inch bore tubes.

	Ft. of Tube.		Cubic Feet.		Fahr.
For 100° Temperature it requires	100	per	1,000	to give	100°.
" 200° " " "	360	"	1,000	"	200°.
" 300° " " "	1,200	"	1,000	"	300°.

These figures are from actual tests. I have never seen any other table on this subject, and I know of no theoretical calculation that will come even approximately near the mark.

You will notice for the first 100 degrees it requires 100 feet of tube, for the second 100 degrees 260 feet of tube, for the third 100 degrees 840 feet of tube, or a total of 1,200 feet, to obtain 300 degrees.

Hence Mr. Thompson's statement "that he had to double his surface to get 400 degrees" would be very much under the actual requirements for this purpose.

Mr. James Mackay says, "To get 80 degrees instead of 70 degrees (presumably from zero) 25 per cent. increase of radiation was barely sufficient."

The Secretary said, "it requires 50 per cent. more radiation to get the extra 10 degrees temperature." You thus get 100 per cent. difference between the statements made by these gentlemen, and in my opinion both of them still underrate the surface required, and that with water at 170 degrees you will require 65 per cent. more surface to give from zero to 80 degrees than you will to give from zero to 70 degrees.

I should like to qualify this by stating that by increasing the water temperature you may decrease this percentage, also that

owing to the colder climatic conditions in the United States, and the buildings being consequently more substantially built, thicker walls, or double glazed windows, etc., the percentage of increase in the radiation required would be less than that required for the English buildings and climate. Hence my estimate may be wrong; if so, I should be glad to be corrected.

Mr. Lewis says, "I would be willing to figure up Mr. Jones's problems. I may not be successful, but it would be interesting." I raise my hat to Mr. Lewis, it is worth trying; all of us are wrong sometimes, and the fact that our calculations vary by 100 per cent. proves that we need to prove our formulas before we accept them as being infallible.

Mr. Widdicombe says, "I bought Mr. Jones's book with the answers in it, and figured back on that." Oh, fie! Mr. Widdicombe, when you see the answer to a conundrum it does not usually require much guessing. I think it was honest for you to admit it, also that "you have tried one of the problems and came within 100 per cent." Try test 22, page 244. This has surprised many experts, and I have not yet met any formula that explains it. We all want to arrive at the truth, and it is by a friendly interchange of opinions that we shall arrive.

I beg to thank all the members of the institution who took part in the discussion for their kind and lenient criticisms. I hope some of them will follow up this subject. I have made a close study of it for years, and cannot yet satisfy myself, but with the help of the members of the American Society of Heating and Ventilating Engineers and the co-operation of the British Institute of Heating Engineers it ought not to be difficult to arrive at a solution.

If one or more of your energetic members will take up the suggestion in the last paragraph of my paper, I feel sure that it will repay you for your time and trouble.

CLXIII.

THE ELIMINATION OF REDUNDANT PARTS IN THE FORCED CIRCULATION OF HOT WATER.

BY A. H. BARKER, TROWBRIDGE, ENGLAND.

(Non-member of the Society, presented by request.)

The system described in the present paper is the outcome of an attempt to utilize two of the properties of steam which chiefly make up its value to the heating engineer—viz., its latent heat and its pressure—in such a way as to eliminate the redundant parts of a pump-circulated hot-water apparatus of the ordinary type.

The standard method of heating water by steam and circulating it, is to use a calorifier or steam-tube heater, and to propel the heated water by means of a duplex pump. If this combination is analyzed into its elements it will be seen that there are several parts which are functionally redundant, and which, therefore, if for no other reason (of which, however, there are many), ought to be dispensed with.

In the heating of the water, for instance, the essential requirement is to transfer the heat of the steam to the circulating water as quickly as possible. In the ordinary method the surface of a metal tube is interposed between the heat of the steam and the water, and all the heat communicated to the water must be conducted through the surface of this metal tube. When we come to inquire into the fundamental reason for the use of this tube, it will be clear that it is not required for the primary purpose of conducting the heat of the steam to the water, because this process will take place much more quickly and efficiently without any tube being interposed. Neither is it required primarily for the purpose of keeping separate the water of condensation from the heated water, for (except in the case of water heated for domestic hot-water supply, in which case the water on the two sides of the tube

surface is different in quality, one being hard and the other soft) there exists no reason why the condensed water should be kept separate from the circulating water.

The really fundamental reason for the use of the tube between the water and steam is not that it is a device for filtering the heat of the steam away from the condensed water, but for filtering the heat of the steam away from the pressure of the steam, if I may be allowed to use such an expression. In other words, the tube interposed between the water and the steam has as its necessary qualifications for its duty (1) the thermal conductivity necessary to allow the heat to pass, and (2) the mechanical strength necessary to retain the steam and to resist the difference in pressure between the water and the steam.

If you have steam at different pressures the heat of which is to be communicated to the same circulating water, it is for the same reason necessary either to reduce the pressure of the higher to the same value as that of the lower, if using only one tube heater, or to use a separate tube heater for each different pressure employed.

There is in the tube-heater system yet another redundant part. When the heat has been filtered out of the steam, the steam itself disappears as steam, and a certain amount of condensed water takes its place. This water must be got rid of somehow, otherwise it will prevent the access of more steam to the heating surface. It must be either returned to the boiler as feed water or thrown away, and here again the existence in this condensed water of both heat and pressure together introduces another set of problems. This water is often at a temperature far above that at which it can exist as water at the atmospheric pressure, and the necessary requirement is to return this water to the boiler as directly as possible, with as little loss of its heat as may be.

The standard or usual method in which this problem is solved is to use a steam trap which is functionally a device for filtering the water away from the steam, which, if it is efficient, drains out the water from the steam without allowing the escape of any steam as such, and returning the condensed water for feed purposes to the boiler chamber at atmospheric pressure. When the water is first transferred by

the trap from the pressure of the steam to the atmospheric pressure, its temperature and pressure are such that a portion of it instantaneously explodes into steam, thereby reducing the temperature of the remainder to such an extent that it can exist as water at the atmospheric pressure. By this process some of the heat of the condensed water is deliberately wasted in order to secure the easy transference of the water freed from pressure, as water, again to the boiler, or, it may be, to the drain.

From this point of view, therefore, the steam trap is seen to be merely a somewhat clumsy device for dealing with the pressure of condensed water and reducing it to the atmospheric pressure by a process of wasting part of its heat.

It will thus be clear that the heating tube of the calorifier and the steam trap are introduced into a heating system solely on account of the necessity of equalizing the various pressures as between the static head of the circulating water on the one hand, the boiler pressure on the other and the atmospheric pressure on the third.

The next series of redundant parts in this system are found in the pump.

The primary function of the pump is to utilize the pressure of the boiler steam in order to press the heated water round the circuit of pipes. Functionally the method by which this result is secured is to place two check valves in series in the water circuit so that the water can only travel one way round. The water space between these two check valves is arranged so that it can continuously be alternately expanded and contracted. Thus water is drawn from the return pipe of the system and delivered into the flow pipe. At some point of the system the heater is fixed for maintaining the temperature.

The method of securing the alternate expansion and contraction of the portion of the circuit between the two check valves, is a water piston and cylinder actuated by a steam piston and cylinder.

Now just as there exists no reason other than the difference in pressures why the water should not be heated by direct contact with the heat of steam without the interposition of a tube, just so there exists no reason, except the difference of temperature, why the pressure of the steam should not be

communicated direct to the water without the interposition of two pistons and a piston rod, and all that they entail in the way of glands, guides, stuffing boxes, etc.

Functionally the reason for the existence of a pump is the exact opposite of that which justifies the calorifier tube. For, whereas the calorifier tube is a means of communicating the heat of the steam to the water without at the same time communicating its pressure, by interposing the substance of a tube between the two, just so the pump is a means for communicating some of the pressure of the steam to the water without at the same time communicating its heat. It does this by interposing two pistons and a piston rod, or pump plunger or its equivalent, between the steam and the water. It is important to notice that both the pump and the calorifier are in reality filters for filtering the heat of the steam away from its pressure. They do this in an opposite sense, the calorifier using the heat and rejecting the pressure, and the pump using the pressure, and if not actually rejecting the heat, at least communicating it to the water by other means.

It will thus again be seen that the reason for the existence of all these redundant parts is the necessity of equating the pressures as between the various parts of the system.

Now the object of this system is to dispense with all these redundant parts (viz., the calorifier tube with all that it entails in the way of traps and valves, the redundant parts of the pump, with all they entail in the way of lubrication, packing and dirty condensation) by tackling the pressure problem. Once that problem is solved, as in this system, the *raison d'être* of all the redundant parts disappears. As is almost invariably the case, the elimination of redundant parts is attended by an improvement in working, ease of manipulation and cheapness of construction, and the present case is no exception to that rule.

The method adopted in this system for the elimination of these redundant parts is in principle as follows:

(1) To release the pressure of water in the return pipe from the static head due to the height of the expansion tank by means of a buoy valve. This produces a powerful circulation in the system of pipes. The water from the buoy valve is delivered on the uppermost of a vertical series of perforated

horizontal trays fixed one above the other within the heater, and falls from one tray to the other in a shower of drops.

(2) To release the pressure of the steam from the boiler pressure through a simple form of load valve into the upper part of the same chamber. The steam thus silently heats the water by direct contact, and the heated water falls into the bottom of the heater.

(3) After being heated the water is allowed to flow into a second vessel, which is practically a float pump, through a check valve. When this vessel is full, steam pressure direct from the boiler is automatically admitted above the surface of the water, and puts the water again under the static head due to the height of the expansion tank by forcing it again into the main without agitation and therefore silently, as fast as it is received from the heater.

In order to avoid the possibility of a rapid change of temperature in the mains or radiators owing to the sudden turning on or cutting off of the steam supply, it is found to be advisable to deliver the water from the ejector direct to the expansion tank, the water in which acts as a sort of temperature buffer between the heat of the steam and the pipes.

The common pressure to which both the water and the steam are reduced depends on the character of the apparatus and the source of the steam to be used.

If, as often happens in large installations, some or all of the heat is derived from exhaust steam from electric-light engines working non-condensing, it is necessary that the reduced pressure should be that of the atmosphere; in other words, that the apparatus should be connected to the atmosphere by an open pipe.

In this case, if there is not enough exhaust steam available to heat the water to the required degree, live steam is turned into the same heater by a thermostatically controlled valve.

If the engines are working condensing the pressure in the heater is the same as the absolute value of the back pressure in the engine (neglecting friction in ports and exhaust pipe). In this case the temperature to which the water is heated can never be greater than the temperature corresponding to that back pressure. With a high vacuum this temperature is insufficient for practical purposes, but with a vacuum of 20

inches of mercury good results can be obtained at 160 degrees. Live steam can be turned into this vacuum just as in the case of atmospheric pressure.

In installations operated by low-pressure steam boilers the pressure maintained in the heater is the pressure corresponding to the absolute temperature to which it is desired to raise the water. The pressure is maintained by a simple combination of valves which regulates it automatically in a simple manner.

The smaller type of apparatus up to about 10,000 square feet capacity has both parts of the apparatus cast in one piece, rendering it very inexpensive and compact. In this case the apparatus is installed in the upper part of the circulating system, the expansion tank being in such position as to maintain a head at the level of the ejector not exceeding the working pressure in the boiler. In this case the very low pressure maintained in the heater produces a powerful suction on the return pipe which, added to the difference of level of the expansion tank and the heater, produces a powerful circulating force even at a very low boiler pressure.

In some cases where the pressure driving the ejector is liable to wide fluctuations—as, for instance, when the boiler is left for long periods without attention—it has been found advisable to use a piston pump instead of an ejector. The steam piston has a large area, so that the pump can be operated against a fairly high head, at pressures much lower than a float pump which works by direct pressure on the surface of the water. Also the employment of a piston pump is found to be advantageous in cases where the amount of exhaust steam available is ample for all requirements. It is, of course, obvious that the piston pump consumes less live steam than the float pump, in which the steam comes into direct contact with the water. This increased consumption of the float pump is of no moment where the live steam has to be employed in heating the water in the heater if not in the pump, but it would be wasteful if there is already an excess of exhaust. The chief disadvantages of a pump of the piston type are (1) that it entails a continual loss of water by condensation which cannot be returned to the boiler on account of its dirty character. (2) It needs continual attention in the way of

cleaning, packing and lubrication. (3) It is also much more expensive than a pump of the float type.

Fig. 1 is a diagram showing the method of connections of the pipes arranged for applying in practice the principles

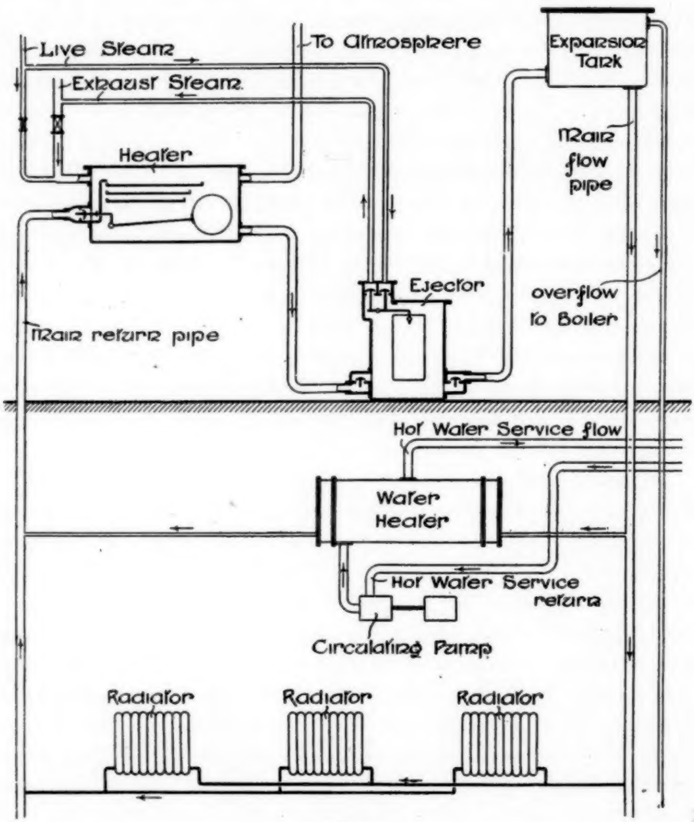


FIG. 1.

enunciated above. Several very large installations are at work in England with the connections arranged exactly as shown here.

Each radiator or series of radiators in the whole installation is connected on the inlet side to the main flow pipe or to a branch from same. The outlet side of the radiator or series of radiators is similarly connected to the return main, so that the

full effect of the circulating power is obtained through each radiator. If the dimensions of the pipes are properly determined, it is therefore impossible for the circulation to fail through any radiator.

The heated water thus put into circulation is used for a great variety of purposes, such as heating, drying, cooking and the heating of other water for hot-water supply to lavatories, sinks and baths. In the latter case the service water is heated by a tube heater receiving its heat from the circulated water.

The originally heated water or primary circulation is not drawn off for any purpose, as this water becomes in a short time practically pure distilled water. It receives a continual accession of pure distilled water from the condensed steam, and parts at the same rate with some of its own bulk, which is redistilled by the boiler and returned to the circulating system as steam, to be there recondensed. In the limit it will be seen that these conditions lead to the ultimate distillation of the whole body of the circulating water, the overflow from which will be pure distilled water for boiler feeding.

In most cases the whole of the secondary supply of water for service requirements is heated by a tube heater fixed in the heater chamber, whence it is distributed by pump circulation to the various points where it is required, so that there is no apparatus whatever outside the heater chamber. In some cases, however, separate tube heaters are fixed near the points where the supply of hot water is required, so that only one set of mains are required. This is economical, both in first cost and in heat loss, but it is found in some cases less convenient, because it prevents the temperature of the whole of the heating circuit being regulated to suit varying weather conditions without at the same time reducing the temperature of the hot-water supply.

Fig. 2 shows a diagram of the connections where a low-pressure steam boiler supplies all the heat both for heating and circulating. In this case the access of water condensed from the steam in the heater results in a continual accretion of water in the circulating system. An overflow pipe is fixed in the expansion tank and is led direct to the boiler as feed, or in some cases where a very constant water level is desired

in the boiler, or where the water capacity of the boiler is limited, to a separate feed tank, whence it is again fed into the boiler through a boiler feeder. Several very large installations on this principle are now at work in England for heating and hot-water supply.

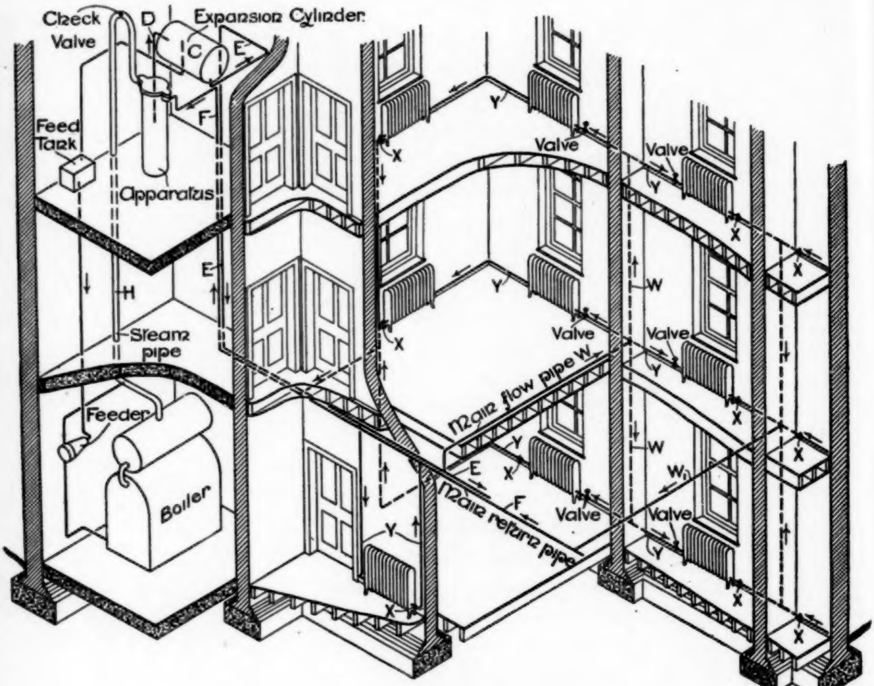


FIG. 2.

Figs. 3 and 4 show diagrammatic sections of the self-contained type of apparatus, many of which are now in use.

There is one large installation in England which contains some unusual features dictated by the peculiar conditions to which I will refer in closing.

The conditions laid down by the client were that there must be no apparatus of any kind within 200 feet of the house. That the boiler pressure must not exceed 15 pounds per square inch. That no steam pipe was to be carried into or

under the house. That the apparatus must be such that it would at any time require a minimum of attention, and that it would run during the whole of Sunday and the whole of every night absolutely without attention and without the presence of an

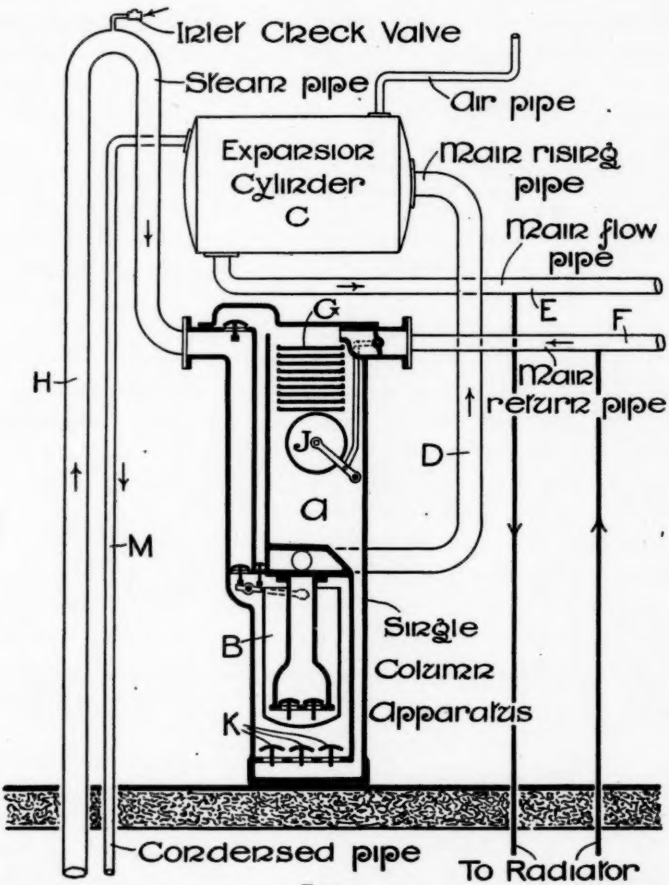


FIG. 3.

attendant being necessary. That it should automatically condense the whole of the exhaust steam given off at any time by a pair of 60 horse-power electric-light engines. That the whole of the apparatus was to be in duplicate, so that either apparatus would do the whole of the work, and that any por-

tion of the apparatus being out of gear would not produce a stoppage. Yet a further requirement was that the hot-water service apparatus must be entirely independent of the heating apparatus; that the conservatory and certain other rooms should be arranged to be heated at will either by the heating system or the system supplying heat to the service apparatus,

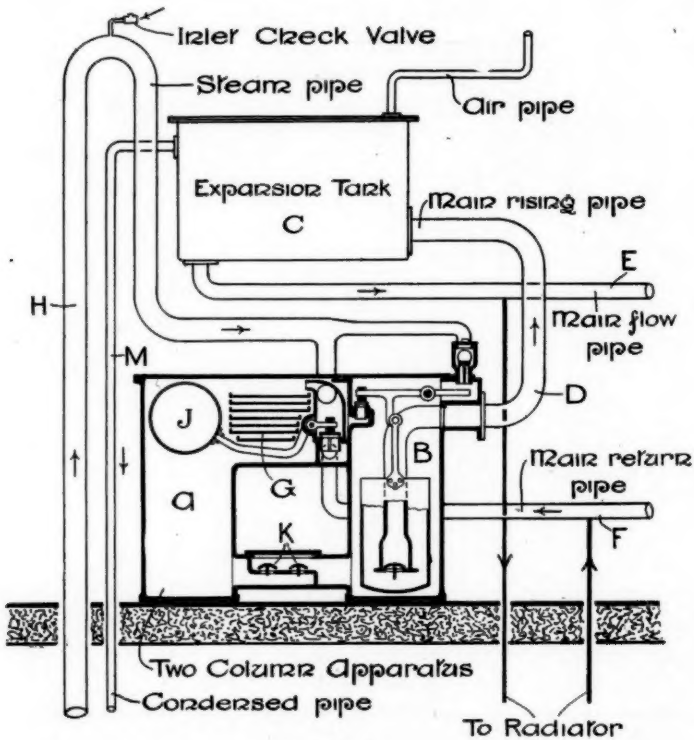


Fig. 4.

and finally that the shutting off of the heating apparatus in summer should absolutely shut off the heat from every pipe passing into the house except the pipes for the secondary hot-water supply system.

The boiler chamber was so low that it was impossible to command the upper part of the house by a tank placed at the top of the boiler chamber. It was, therefore, necessary to

provide two entirely separate systems, one with a relatively high pressure or head, in order to command the radiators on the third floor of the house for heating purposes, and the other with a relatively low head owing to the impossibility of placing the tank at a sufficiently high level, there being no building except the house itself sufficiently high, and the presence of a hot tank in the house in the summer months being forbidden.

The boiler pressure had to be not more than 15 pounds per square inch, which made it impossible to reach the top of the house by direct pressure, so that a pair of reciprocating pumps had to be supplied with large steam pistons to overcome this pressure. The boilers had to be sectional cast iron arranged for automatic self-regulation, and the pressure in them was too high to allow them to be fed by gravity direct from the low-level primary expansion tank for the supply of heat to the service system. Further, the necessity of running the two systems simultaneously and of feeding the boilers automatically from either or both systems, and the certainty that the accretion of water from the condensed steam from the electric engines would intermittently overflow from both systems (all of which surplus water could not be allowed to get into the boilers, as it would, of course, have completely flooded them), made up together one of the most difficult problems that I have ever had to deal with.

I solved it, however, quite satisfactorily by means of this apparatus, and the installation has now been at work under the above conditions for some months.

The method of solution was as follows: Two identical systems are arranged exactly as shown in Fig. 1, except that on account of the high level of the heating system tank it was necessary to employ two similar duplex pumps, one for each service, instead of the float pumps indicated in Fig. 1.

On account of the necessity for the automatic regulation of the boilers steam is provided by three large sectional cast-iron boilers, having large fuel capacity and working at from 7 to 12 pounds per square inch.

The main exhaust pipe from the electric engines after passing through an oil separator is connected direct to the heaters with free outlet on the other side to the atmosphere. When

the engines are stopped or when the steam from them is insufficient, steam from the low-pressure boilers is admitted through a load valve.

The heating or high-level expansion tank is fixed at the top of the house, and the heating pump, operated by steam from the sectional boilers, delivers the heated water into this tank, whence it is distributed to the radiators, returning to the pump chamber to be reheated.

The low-level expansion tank is fixed at the top of the boiler house, and the circulation from this tank operates a pair of tube heaters under the house 200 feet away. From these heaters a natural secondary circulation is secured to the draw-off taps. The conservatory, the billiard room, and some other radiators are connected by special duplex valves to either system, so that it is impossible to open one without at the same time closing the other. This avoids any possibility of emptying the high-level system into the low-level system by any carelessness in leaving both valves open.

The satisfactory feeding of the boilers was the greatest difficulty. It was not possible to feed from the high-level system only, as this would have allowed all the steam condensed in the low-level system to escape, and would have called for a continual supply of hard water to the boilers to make up for this loss. On the other hand, the height of the low-level expansion tank was not sufficient to enable this water to be fed into the boilers by gravity.

This difficulty was got over as follows: The overflow from the high-level expansion tank is led into the low-level expansion tank, which therefore receives the whole of the surplus water condensed from the electric exhaust, as well as the water condensed from the steam supplied by the low-pressure boilers to the apparatus.

The expansion tank of the low-level system is connected to a return trap, and the water from the return trap is fed into the boilers through a pair of automatic boiler feeders, which only allow the trap to feed into the boilers as much water as is required to maintain the water level. The overflow from the low-level expansion tank is led into the main feed tank, from which the feed supply to the main high-pressure electric-light boilers are fed.

The low-level expansion tank is thus kept always full, and any condensed make-up required to replace the little water lost in the condensation in the pumps (which cannot be returned to the boilers on account of its greasy character) is thus supplied, and there is no danger of flooding the boilers.

The boilers have sufficient fuel capacity for a 12 to 15 hour run at low power, and the only regulation required in the apparatus is the adjustment of a jockey weight on the lever of the automatic regulator controlling the draft in the boilers, which without any other adjustment whatever controls the whole apparatus from the lowest to the highest powers.

There are many other installations in England in which the only attention required to the system is stoking three times in 24 hours, the apparatus working day and night and producing automatically all the results obtainable from a pump system.

This is sufficient to show that the elimination of redundant parts is in this case, as usual, attended with an improved simplicity of working.

DISCUSSION.

The President: Gentlemen, the paper is now before you for discussion. We have the original drawings on a larger scale for those who care to examine them more minutely.

The Secretary: It is unfortunate, Mr. President, that Mr. Barker, the author of this paper, is not present with us. He fully intended to be here, and wrote me at that last minute, I received his letter this morning; he was very much disappointed at his not being able to be here. He says any replies wanted he will gladly send by mail, so that if the members will discuss it now, or if they will send me their written discussion it will be forwarded to Mr. Barker, and, as he says, will be fully replied to by mail by him.

Mr. Donnelly: I would like to have some further facts in relation to sizes and distances. For instance, the author does not tell us how much tray surface is sufficient to heat a given amount of water. It would be interesting to have some data in regard to the necessary tray surface to heat water for a given amount of radiator surface. Also as to his size of piping, it would be in-

teresting to several of the committees. In connection with the apparatus as shown in Fig. 1, I don't think he has made his drawings liberal enough or gone into details. It seems to me the header and ejector must have some intermittent means of working the floats; but as here shown they are continuously operating floats. It seems to me it must have some intermittent means of operating the two valves, which would tend to make it more complicated than it is shown. I think he has made a mistake in not showing any operative device. I am glad to see a man in England introduce a system of water heating, whether he writes a paper on it or not. I think it is a valuable addition to our literature. The paper is incomplete as regards definite information on the question of the methods of construction and so forth.

Mr. Kinealy: I would like to ask Mr. Donnelly if in Fig. 1 it shows that the apparatus is not operating?

Mr. Donnelly: Why, that is the ejector, that is the same thing as a pulsometer pump, isn't it, Mr. Kinealy?

Mr. Kinealy: It seems so.

Mr. Donnelly: A pulsometer pump is intermittent, it works first from one body of water to the other; this shifts the steam first from one portion over to the other. Now this, as I look at it, must wait until it empties, and then it must drop and shut off the water, it must have a valve motion.

Mr. Kinealy: That is shown there.

Mr. Donnelly: Yes, that is a valve motion; if the water went up a few inches it would open. This float is shown directly connected with the rod and the ejector; as I see it, there is no lost motion in any part of it; the same as an automatic return drip, or return boiler; there is weight there that causes it to go first from one side and then to the other and back again.

Mr. Kinealy: As I see the picture in Fig. 1, it consists of an outer casing on which there is a float, and which float is connected at the top to a horizontal rod which moves about a point, the point being shown by a small circle, and to the left there is a check-valve that allows the water to enter the outer chamber, which prevents the water from flowing out; on the right is a check that allows water to flow out, but prevents it from flowing back. Now, when water flows in along the heater, which is above the ejector, the ejector fills with water and the float rises and

closes the valve in the upper left-hand corner of the pipe, leading to the exhaust steam, and opens the valve in the pipes leading to the live steam; the live steam then presses down on the top of the water and forces the water out through the right-hand valve at the bottom, until all the water has passed out, and then the floats drop, the valve is closed in the pipe leading to the live steam, and the exhaust pipe is opened so that the water can come in again. It seems to me that is shown right here clearly.

Mr. Donnelly: Why, yes, but there is no means shown of closing the steam valve before the exhaust valve opens. That might be shown at the same time on the cut. That sketch is on a very small scale; you first have to close the exhaust valve and then afterwards open the steam valve, keeping it open for a certain length of time, and emptying into this tank, because the pressure in this ejector must be greater than that of the heat flowing through the heater. Incidentally, the tank must be on a higher level than the heater, in order to get a gravity float from the expansion tank from the apparatus to the heater; therefore there must be an intermittent valve motion. When the water goes back to the ejector it must open the exhaust valve and close the steam valve; there must be an intermittent action of these valves.

Mr. A. H. Barker (author's reply, added since the meeting): In reply to Mr. Donnelly, who complained of the lack of data on the paper, I would say that it would have been impossible for me to give all the dimensional details of the apparatus within the limits of a short paper, intended only to describe the principles of the system.

I have investigated experimentally during the past five years almost every dimension of the apparatus, and if I had given all such particulars there would not have been time to read this paper at the midsummer meeting at all.

In regard to the sizes of piping one of the great advantages of this system is the great reduction in sizes of pipes which it renders possible. Almost all my radiators are connected up with ¼-inch pipe, and I have worked out a very accurate method of determining the size of mains which, however, it is impossible to describe within a reasonable limit of time, but which I should be pleased to describe for the committee now sitting on this subject if desired.

The reduction of size will be evident when I say that a 2-inch

main not exceeding one hundred feet long will on this system carry 5,000 square feet of radiating surface.

In regard to the method of working the valves on the ejector, the principle is similar to that shown on Figs. 1, 3, and 4, with the addition of a simple trip gear which is entirely satisfactory in practice which obviates any danger of the apparatus getting hung up on a dead point. In one installation a large apparatus exactly as here shown has been operating night and day, winter and summer, for two years without attention of any kind except stoking by a laborer, who, to my certain knowledge, has not the slightest idea how it works, and I doubt whether he has ever even seen the apparatus—certainly never the inside of it.

Professor Kinealy's description of the working of the ejector is very clear and precise. Mr. Donnelly's objection evidently arises from the absence in the drawing of the simple overbalance trip gear which I have designed for this purpose. I would again explain that one cannot show small details of that kind on a small scale drawing designed only to demonstrate a principle.

He may accept my assurance that it is an extremely simple and reliable gear and can be relied on to take care of itself until it wears away through a $\frac{7}{8}$-inch steel rod.

CLXIV.

NOTES ON THE USE OF FEED-WATER HEATERS IN CONNECTION WITH HEATING SYSTEMS.

BY WM. G. SNOW.

(Member of the Society.)

While it is a fact, with which Heating Engineers are familiar, that every 10 degrees rise in the feed-water temperature corresponds to about one per cent. saving in fuel, this gain in economy is apparently frequently overlooked by manufacturers and owners. Feed-water heaters faulty in design or of insufficient capacity are installed; condensation is allowed to go to waste, the heat in which could easily be utilized; live steam is used where exhaust would do as well; and heat units which should be saved are lost in other ways.

It is the purpose of this paper to point out certain features in the application of feed-water heaters in connection with heating systems.

In certain kinds of manufacturing plants having many hot greasy drips from machines, this water is made to flow through the pipes of a horizontal heater as illustrated in Fig. 1, the boiler feed water filling the space between the tubes and the shell.

Exhaust from pumps and other apparatus may be discharged through the same heater if desired.

The coldest feed water surrounds the lower pipes containing the least hot drips, so that they pass from the heater to the sewer at relatively low temperatures, having transferred most of their heat to the feed water.

The flow of hot condensation through such heaters is apt to be irregular, and in most cases would be hardly sufficient to bring the feed water to the desired temperature, therefore it is customary to use a regular " closed " heater as a reheater supplied with exhaust steam from the main engine.

Valved by-passes are provided as indicated for use in case of repairs or cleaning.

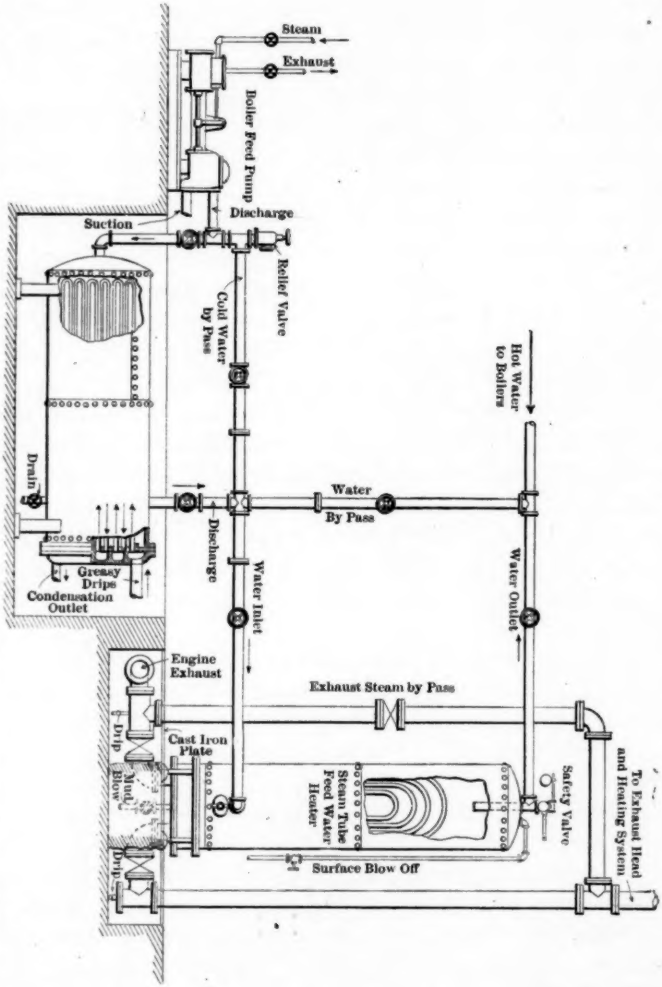


FIG. 1.—SHOWING ARRANGEMENT OF CLOSED FEED-WATER HEATERS IN CONNECTION WITH HEATING SYSTEMS.

In some buildings, cold water en route to the feed-water heaters is forced through coils placed in drip tanks and blow-off tanks for the purpose of utilizing some of the heat that would otherwise be wasted, and to provide for cooling the

water that would cause injury to sewer connections if discharged at too high a temperature.

Until recent years the method most commonly adopted in large city buildings is shown in Fig. 2.

The receiver should be placed well above the suction valves of the pump to provide sufficient head to cause the water to properly follow the piston and prevent the racing of the pump.

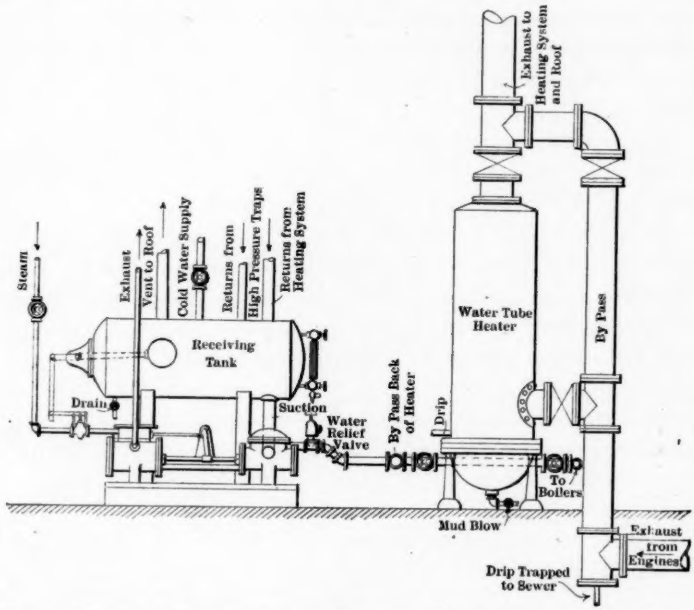


FIG. 2.—SHOWING ARRANGEMENT OF PUMP AND RECEIVER AND CLOSED FEED-WATER HEATER IN CONNECTION WITH HEATING SYSTEM.

Closed heaters are of the steam-tube or water-tube type, the expansion of the tubes being provided for, as a rule,

(1) By the use of " U "-shaped tubes.

(2) By tubes fixed at both ends, the drum at one end being fitted with an outlet pipe working through a stuffing box.

(3) By means of corrugated tubes fixed at both ends.

(4) By the use of coils of brass or copper pipes.

Tests on water-tube feed-water heaters are stated to have shown that when the water was pumped through the heater at such a rate that the final temperature was within 15 degrees

of the temperature of the steam, the transmission per square foot of tube surface was about twice as great as when the water was pumped through so slowly that its final temperature was within 5 degrees of the temperature of the steam.

This shows that when a closed heater of this type is forced the efficiency of the heating surface is greatly increased, due to the greater difference between the temperature of the steam and the average temperature of the water, and to the more rapid rate at which the water is forced through the tubes, insuring a more complete contact between all portions of the water column and the heating surface than when the rate of flow is slower.

Steam-tube heaters have a relatively small overload capacity on account of the sluggish circulation of water between the pipes and the shell.

The capacity of closed heaters is commonly based on one-third of a square foot of heating surface per horse-power. On the basis of 30 pounds of water per horse-power raised from 50 degrees Fahr. to, say, 200 degrees Fahr. the heat transmission per square foot of surface per hour would be 13,500 heat units.

It is probably safe to say that closed feed-water heaters bought in competition are seldom provided with sufficient surface to raise the temperature of the boiler feed water to more than 200 degrees.

Closed heaters of the steam-tube type must have shells strong enough to withstand a pressure in excess of that in the boiler.

A relief valve should be placed in the pump discharge line, otherwise excessive pressure will be produced in the heater when the boiler feed valves are suddenly closed, and will cause undue wear and tear.

Heaters arranged to circulate steam through the coils, the water occupying the space between the pipes and the shell, deteriorate, as a rule, more rapidly than when the water circulates through the coils surrounded by steam.

Cast-iron shells are preferred by many engineers to those made of steel plate on account of their greater durability.

Steam-tube heaters provide much greater storage capacity for hot water than do those of the water-tube type.

Storage capacity means that more time is afforded for the settlement of impurities, any heavy sediment being removed through the mud-blow, lighter impurities being discharged through the surface blow-off.

The piping in Figs. 1 and 2 show full-sized exhaust connections, which are commonly employed to give the most efficient circulation of steam through the heater. The condensation from this steam is wasted to the sewer.

Since only a portion of the exhaust steam is condensed, branch pipes to and from the heater considerably smaller than

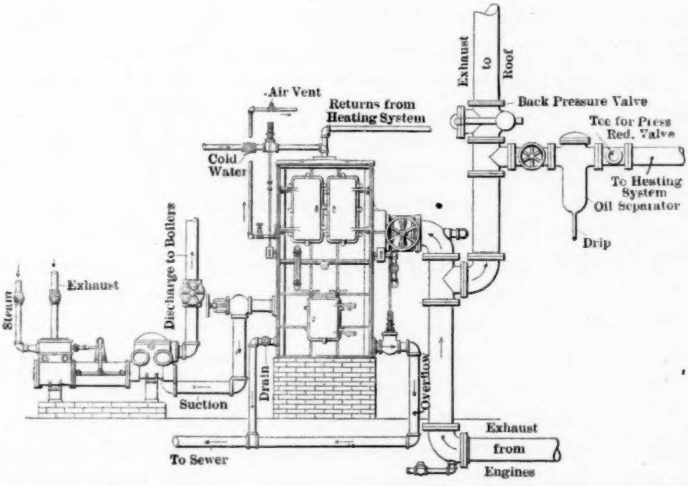


FIG. 3.—ELEVATION SHOWING ARRANGEMENT OF "DIRECT CONTACT" OR OPEN FEED-WATER HEATER IN CONNECTION WITH HEATING SYSTEM.

the main exhaust pipe are sometimes used. When this is done care must be taken to properly vent the heater to prevent air binding.

When water-tube coil heaters are used, one or more coils are sometimes conected with the hot water tank or generator that supplies hot water to the building on the same principle as a water back in a range, the water being reheated by live steam coils in the tank.

Fig. 3 illustrates a modern apparatus and connections for handling the condensation from a heating system, at the same time providing for the heating of any additional water supply

required by the boilers. The feed-water heater of the type shown combines the functions of heater, oil separator, and receiver for returns from the heating system.

It is unnecessary to force all the exhaust steam through a feed-water heater of the direct contact or open type, since the condensation of about one-sixth of the engine exhaust is sufficient to heat the water necessary to take its place in the boiler.

Assume, for example, that the engine is exhausting to the atmosphere with practically no back-pressure. The latent heat of steam at atmospheric pressure is 966 heat units. To heat 1 pound of water from, say, 50 degrees to 210 degrees, requires 160 heat units, equivalent to the amount contained in about one-sixth pound of exhaust steam. If all the exhaust steam is passed through the heater about five-sixths of it passes up the exhaust pipe uncondensed, and the passing of this oil-laden steam through the separator and the heater imposes an unnecessary burden on them, besides adding to the cost of the piping due to the by-pass required.

A valved by-pass, aside from the cost, introduces an element of danger, since in case of faulty operation of the valves, the heater would be subjected to an excessive pressure which would be likely to cause its disruption.

With open heaters practically no resistance is offered to the ingress of exhaust steam, hence no appreciable increase in back pressure on the engine is necessary to keep these heaters properly supplied with steam.

The efficiency of " open " heaters is not seriously impaired by deposits of sediment or scale on the trays, since the steam and water come in direct contact. The main criticism raised against them by some engineers is the dangers from oil getting into the boilers.

Of course the character of the water has much to do with the selection of a heater, the open heater being very commonly used in sections where bad water is encountered. This type of heater affords ample space for the settlement of organic impurities, and the high temperature secured precipitates the carbonates of lime and magnesia, which are deposited in a settling chamber provided for the purpose.

To precipitate the sulphates, temperatures in the vicinity of

300 degrees are required which are far beyond the range of exhaust steam heaters.

This paper, however, is not a treatise on chemical heaters, although those of the open type are frequently fitted with tanks and apparatus for introducing chemicals for softening the water, which must be supplied in addition to the returns from the heating system or during the season when heating is not required.

Returning now to the question of eliminating the oil contained in the steam, the greater portion of this is removed by the separator; the coke filter, some 18 inches thick, being depended on to reduce the amount left to a harmless percentage. These heaters may easily be re-coked; in fact, all portions of the interior are accessible through large doors made tight by the use of gaskets.

The great and increasing number of such heaters in daily use would appear to the unbiased to be pretty satisfactory proof that the oil question is successfully disposed of.

Some engineers object to the pumping of hot water, which is necessary when using direct-contact or open heaters, they claiming that the hot water causes rapid deterioration of packing and valves. When the heater is set sufficiently high to bring the water level 3 feet or more above the suction valves of the pump, no trouble should be experienced in pumping hot water, as there will then be sufficient head to cause the water to follow the piston and prevent racing.

Sometimes when a heater is set low with reference to the pump, the substitution of lighter springs on the suction valves will overcome racing that may have been experienced.

As to the best material to use for valves for hot-water service, many engineers prefer all metal valves instead of hard rubber. Such valves give good service and are considered by many to be worth the additional cost. Somewhat more care must be exercised in selecting piston packing than for cold-water pumps, especially in the case of end or center-packed plunger pumps, but this is only a detail, and hundreds of plants have pumps working successfully under the conditions stated.

The great storage capacity for hot water in direct-contact or open heaters is an advantage in meeting any sudden increase in the load on the boilers.

The condensation returned from the heating system is from steam that has passed through a separator. After this condensation has passed through the coke filter in the heater, it is in condition to be returned to the boilers.

All steam condensed in heating the water in the heater is likewise returned to the boilers, and is no inconsiderable item of economy when water must be bought at city rates, amounting, as it does, to not far from one-seventh of all the water required.

There is no denying the fact that a greater amount of attention and more intelligent service is necessary when the most efficient modern devices are used to save fuel. The extra cost of such additional attendance is, however, often a small item in comparison with the saving secured.

DISCUSSION.

Mr. Donnelly: To start the discussion, I would like to ask Mr. Snow, in giving the relative surface for his job of heaters, what is the amount of tray surface per horse-power for this job?

Mr. Snow: I should say roughly about one-tenth as much as on a closed type of heater; possibly not very far from that. That is merely the tray surface. Of course we have a large area of water that is in contact with the exhaust steam as well, not included in the tray surface, not commonly computed as heating surface in that class of heaters.

Mr. Stannard: I should like to ask Mr. Snow, referring to the statement that the efficiency of open heaters is not affected by the fouling, are not most of the heaters equipped with perforated trays in which the column of water coming through is more or less broken up?

Mr. Snow: A good many of them are; but those perforations occur only in special types of heaters, and this paper was written treating of open heaters in general, not any specific type; that is why I did not lay any stress on perforations.

Mr. Stannard: In my experience, I find fouling of the trays does cut a considerable figure in keeping the water to a high temperature.

Mr. Snow: There are a number of heaters of the open type made without these perforations.

Mr. Kinealy: I won't say anything about the heater, but I want to say something about the connection. In Fig. 3 you will notice that the exhaust pipe leading to the heater is an ordinary elbow drip taken from the bottom of the elbow. In Fig. 2 there is a " T " drip taken from the run of the " T." It seems to me the connection shown in Fig. 2 is better than the connection shown on Fig. 3. What do you think of that, Mr. Snow?

Mr. Snow: I agree with Mr. Kinealy; both Figs. 1 and 2 are shown with the " T," and the other with the elbow. I think the " T " is a preferable connection, giving a pocket as it does for the collection of condensation.

Mr. Kinealy: Yes; I have had two instances where water was retained in the exhaust pipe and the engine smashed, and all we did was to change the elbow to the " T," and drip from the bottom of the " T," and had no more trouble.

Mr. Snow: I have probably piped up more of them with the " T " than with the elbow, although I have used both successfully. I simply showed the different ways on the different cuts.

Mr. James Mackay: Is it not rather a matter of competition? The " T " costs a little bit more than the elbow, and, on that subject, is it not true that when a thing is bought in competition on the open market it is just as likely to be short of surface with the open as it is with the closed one? Don't the same thing apply to everything as well as to the closed heater?

Mr. Snow: Well, that is an interesting question. I don't know that anything is stated to the contrary. I investigated that matter, and what I wrote is based upon my investigation.

Mr. Stannard: I want to ask Professor Kinealy if the filling of the pipe and the breaking of the engine was not due to the overflow of the heater, and not simply due to condensation from the engine itself, and if it would make any difference whether there was an elbow there or a " T " in a case of that sort?

Mr. Kinealy: Of course I don't know where the water came from; the engine was smashed.

Mr. Stannard: I imagine it was from the overflow; I have had cases where the fault was due to the overflow of the heater rather than to condensation.

Mr. Kinealy: Possibly if we simply put the elbow back we might have had no more trouble.

Mr. Stannard: The main thing is to get a heater that will not overflow into the exhaust pipe.

Mr. Snow: This is guarded against in open heaters either by a simple water seal or by an automatically operated overflow valve, according to the back pressure to be carried.

CLXV.

FADS AND FALLACIES IN HOT-AIR HEATING.

BY R. S. THOMPSON.

(Member of the Society.)

That I may not seem to claim all wisdom in this matter, I ask you to interpolate the words "it is my opinion" before each of my statements. These are my "opinions" based on study, observation and experience. Some of them will probably commend themselves to your judgment. Some may be fads of my own. Some may themselves be fallacies. I believe they are all worthy of your consideration and discussion.

It is a fallacy to suppose that a set of rules can be formulated by the observance of which any man can heat any building. In no two buildings will exactly the same conditions be found. Each building is a proposition to itself. Without an intelligent comprehension of the principles involved, an ability to closely examine conditions, ascertain causes, reason from effect to cause and from cause to remedy, a set of rules may be more of a hindrance than a help. There is no profession in which "a little learning" is more often "a dangerous thing."

Something over a year ago I was called to examine a large church, the heating of which had been a perplexing problem for more than a generation. The auditorium was always cold for at least two or three feet above the floor. I noticed that even when the church had been long heated there seemed to be downward currents of cold air.

There was unanimity of opinion that something must be done to draw the cold air off the floor. One party had suggested putting in an electric fan and pumping it out. At one time the plan had been tried of cutting off the bottoms of the doors into the vestibule and leaving open the door from the vestibule into the tower. The draft of the tower had caused a strong outward flow of cold air under the doors, but the congregation complained so bitterly of cold feet that the plan was abandoned.

After learning all I could about the plans which had failed, I proceeded to diagnose the case. I had all three furnaces fired to the limit for three hours, and then sought carefully for evidences of "back pressure." I found none. Instead I found at the bottom of every door and window a strong inward current of air. That explained the situation. The building was leaking at the top—leaking so badly that all the air the furnaces could supply was being lost by leakage, and more was being drawn in from outside, which, being cold, of course settled on the floor. Had I followed the rule "draw the cold air off the floor" (which is the correct rule when a room is "air-bound" and there is "back pressure" on the furnaces), I would simply have drawn in more cold air to settle on the floor. This explained the failure of the plan to use the tower as a pump. This explained the downward currents of cold air.

As the leaks could not be stopped, the only remedy was to pour in hot air faster than it could leak out at the top, and so "push" the cold air off the floor.

I examined the furnaces and found that when working up to the limit the three could deliver about 1,400 cubic feet of air per minute. I took out two of them and put in two others with a combined capacity of 4,000 cubic feet per minute, putting in larger pipes to allow this larger flow. With these two going I again examined the building and found air flowing out gently under all the outer doors, but not enough "back pressure" to interfere with the operation of the furnaces. The congregation have not had cold feet since.

It is a fallacy to suppose that you can determine the amount of heat needed for a room or building by ascertaining its cubical contents.

Heat once put into a building would remain there for ever, and a building once heated would require no further heat to maintain the temperature were it not for leakage of hot air out and leakage of cold air in and conduction of heat through the walls. But leakage and conduction both depend entirely on wall surface, and not at all on cubic contents, so that wall surface is the only thing to be considered.

I have adopted a rough and ready rule which works well in most cases with the average house, but which, like all other rules, must be used with common sense.

"Divide the number of square feet exposed wall surface by 2. The product is the number of cubic feet of air at 140 degrees that will be required per minute to maintain a temperature of 70 degrees with the outside temperature at zero." *

Of course it is up to the engineer to determine how many cubic feet of air at 140 degrees any given furnace can supply, and how many cubic feet per minute each pipe can deliver. Rough and ready rules will not do in this estimate; an 8-inch pipe will

* As there has been some inquiry about this rule I will give the principle on which it was worked out.

I assumed the common rule that in a house of the average residence type, with a normal amount of glass surface, there will be a loss by radiation and conduction of 38 B. T. U. per hour for each square foot of exposed wall surface, when the difference between inside and outside temperatures is 70 degrees. In this calculation the entire exposed wall surface, including glass, is taken.

One cubic foot of air in cooling from 140 degrees to 70 degrees is supposed to give up $\frac{70}{55}$ B. T. U.

Now take my rule that the loss by radiation and conduction from two square feet of exposed wall surface will be made good by one cubic foot of air per minute or 60 cubic feet an hour, at a temperature of 140 degrees and see how it works out.

$$2 \times 38 = 76.$$
$$\frac{70}{55} \times 60 = 76.$$

At first sight this may seem entirely too close for safety, but in reality it allows a very liberal margin of safety.

In the first place, it is calculated on maintaining every part of every room in the building at a temperature of 70 degrees above that outside, something very rarely required.

In the second place, it is based on the use of air at a temperature of 140 degrees, and in emergencies a much higher temperature can be used. By increasing the temperature of the air 35 degrees, or to 175 degrees, the available heating power is increased 50 per cent., and by increasing it 70 degrees or to 210 degrees the available heating power is increased 100 per cent. The latter temperature would not be an excessive one to use for a short time during specially cold weather.

So it will be seen that this rule provides for proper heating under all ordinary conditions, using air at a temperature of 140 degrees with a possible increase in emergencies of 100 per cent.

Of course to have this margin of safety you must have a furnace which will supply the quantity of air called for by the rule, at a temperature of 140 degrees with moderate firing. If to get this quantity of air at this temperature it is necessary to fire the furnace to the limit, you have no margin of safety. But in my judgment the furnace should always be large enough to meet all ordinary requirements with moderate firing, which is less wasteful of fuel and less injurious to the furnace.

deliver more air under some conditions than a 12-inch pipe will deliver under other conditions.

It is a fad to cover hot-air pipes with a thin sheet of asbestos paper, in order to "keep in the heat." The rough surface of the paper is a better radiator than the bright surface of tin or galvanized iron, and this more than balances the slight gain from the non-conducting power of the sheet of paper. Being spongy, it retains moisture and rots the pipes. The only good purpose I have ever known it to serve is to hide bad joints and botch work. If you must use asbestos, put on half an inch.

It is a fad to set the furnace under the northwest corner of the house with the idea that the air will travel through the pipes more readily in the direction the wind is blowing. Air, while in the pipes, does not know and does not care which way the wind is blowing. Set the furnace where you can reach all the rooms with the shortest pipes and the fewest angles.

It is a fallacy to suppose that you must put a register in the coldest part of the room in order to heat it. It is no warmer six inches away from the current of air that flows from a register than in any other part of a room. The air issuing from a register goes directly to the top of the room, and all heating with hot air is from above downward, no matter where the registers are placed. I should like to try the experiment of heating a house with all the registers in the ceilings. It would at least be a novelty, and I believe would have many advantages.

It is a fallacy to put a register near an outside door or window in order that the wind which blows in through the cracks may drive the hot air over to the back part of the room. If the furnace is working properly there will be an outflow instead of an inflow of air around doors and windows. If the hot air enters near these leaks it will flow out through them and the cold air will be pocketed in the back part of the room. Put your register as far away from the outlet as you can and the hot air in making its way to the outlet will force the cold air out first.

It is a fallacy for a man to suppose that he can wait till his house is nearly finished before he places his furnace contract, and then get good results.

The furnace contract should be let before the excavation for the foundation is begun. As soon as the contract is let the engineer should take the blue prints or tracings of them and lay off

on them the entire plan. The location of the furnace, the smoke pipe, the leader pipes from furnace to first floor register boxes and stack foot-pieces, the stacks, floor-runs, if any, and second floor registers should all be shown. The size of every pipe, stack and register should be given. Then these plans should be gone over with the owner to see that the location of the registers does not interfere with his plans for arrangement of furniture. This settled, copies of these plans should be given to the building contractor with instructions that as the building progresses openings for pipes are to be left as shown on plans, and that plumbers, electricians and other contractors are not to use these openings nor obstruct the access thereto.

The first clause in the furnace contract should provide that the building contractor is to observe the specifications and plans of the heating engineer the same as he does the specifications and plans of the architect.

It is a fallacy for a man to suppose he can give the building contractor the contract for putting in the wall stacks and registers, and then at any time have a " furnace-man " put in a furnace that will heat the house. When I am called on to put a furnace in a house where the pipes were put in by the building contractor I always agree to guarantee those rooms with which I make connections, but tell the party he must go to his building contractor for a guarantee on the rooms for which he put in the pipes.

It is a fallacy to suppose that you can put in a furnace on plans provided by the average architect and afford to guarantee the job. The shoemaker should stick to his last and the architect should stick to his architecture. Not one architect in a hundred has a thorough theoretical knowledge of heating and ventilation, and probably less than one in a thousand has any practical knowledge on the subject. Both theoretical and practical knowledge are needed to secure a successful job. When I am brought a plan on which the architect has laid out the heating work, and asked to follow his plans and specifications, I tell the party that he must go to the architect for a guarantee on the results of the architect's work.

It is a fallacy for a man to suppose that he can have his architect advertise for bids on a heating plant and let the contract to the lowest bidder and have a properly heated house.

Where this is done the man who gets the contract is the one who has based his estimate on the smallest furnace, the smallest pipes, the cheapest material and the poorest job.

When a test is made he sends an expert fireman, who stands over the furnace with a poker and makes it come near enough to fulfilling the guarantee that the purchaser thinks it better to pay than have a lawsuit.

And from that time on the purchaser has troubles of his own. And he tells all his friends and neighbors that if they ever build they should put in steam or hot water. Hot air is a failure; he knows, for he has a hot-air furnace in his own house.

It is a fallacy to suppose that any old pipe of any old size put together in any old way will carry hot air. The force that carries hot air through a pipe is not sufficient to overcome any considerable resistance. Every care should be taken to reduce friction to the lowest point, to avoid eddies and prevent rebound from having the air strike a surface at right angles to its course. When the pipe is long greater size must be given to make up for the lower velocity. Two 45 degree angles are better than one 90 degree elbow, especially if put at a considerable distance apart. In the language of Gladstone, modified to fit the case, it is the province of the heating engineer to make it as easy as possible for the air to pass through the pipes and as difficult as possible for it to refuse to do so.

It is a fad for people in furnace-heated houses to open windows in order to get fresh air. People have an idea that air is not pure unless it is cold, and that unless they can feel a cold draft on the back of their necks they are not getting ventilation. I once overheard a lady remark in church:

"No, I don't think the church is too warm, but there is not a window open, and we shall die for want of air."

And I knew that at that very minute the furnaces were pumping in over three thousand cubic feet a minute of fresh air from out of doors.

These people remind me of the traveler who when stopping at a hotel woke up nearly suffocated, but slept sweetly till morning after he had broken a window—into a book-case—in order to get fresh air.

A house heated by hot air needs no ventilation but what the furnace gives it. If the house is too warm cut down the fire.

It is a fad to talk about furnace heat as a "dry heat." Heat not being a substance is never either wet or dry. Air when heated becomes "drier," that is, its capacity to absorb moisture is increased. But it is the heating of the air that makes it drier and not the method by which it is heated. It makes no difference in this respect whether the air is heated by contact with the iron in a furnace, or the iron in a radiator, or the iron of a stove.

If people want moist air make provision for moistening it, but I always wonder why the wise physicians who talk about the injury to the lungs from the "dry air of furnace-heated houses" send their patients with lung trouble to recover in "the pure dry air of Colorado and Arizona."

It is a fallacy to suppose that if a furnace heats a house it is necessarily a good furnace, and if it does not it is necessarily a bad furnace. Given two furnaces which can each deliver at the casing top the same number of cubic feet of air per minute, at the same temperature, one may be a good furnace and the other a bad one, but one will heat a house as well as the other. They may differ in fuel consumption, in cleanliness, in ease of management, in durability and in many other points, but in the ability to heat the house there will be no difference.

A furnace is a machine for the manufacture of hot air. That is all it is made to do and all it can do. The problem of manufacturing this hot air with the least expenditure of fuel, the problem of producing a machine for the manufacture of hot air which shall be cleanly, easy of management and durable are problems for the furnace manufacturer. But the problem of getting this hot air equally distributed through the various rooms of a house, and so properly heating the house, is a problem that rests solely with the heating and ventilating engineer. Given a furnace, good or bad, which can produce the requisite quantity of hot air at the requisite temperature and the proper heating of the house depends *wholly* on the hot-air pipes and ventilating arrangements.

The poorest furnace ever built, if large enough to furnish the requisite quantity of hot air, will heat any house if the engineering work is properly done.

The best furnace ever built will not heat two rooms if the engineering work has not been properly done.

It is the proposition of the man behind the gun.

This accounts for the fact that you will often find two men, using the same make of furnace, one of whom will declare it is the best in the world and the other is equally sure it is the worst. One is giving the furnace credit that belongs to the engineer; the other is placing on it blame which is due to the engineer.

It is a fallacy to suppose that leader pipes in the basement must have an inclination or "pitch" of one inch to the foot in order that the hot air may flow through them.

The ascensional force of hot air (if I may be allowed to coin a word) depends on the difference in elevation between the starting point and point of delivery. It will make no difference whether the air is carried six feet perpendicularly and twelve feet horizontally, or five feet perpendicularly and twelve feet at an inclination of one inch to the foot. What you gain in the pitch you lose in the riser. If I *had* to take my pipes off the side of the casing I would carry the casing up to within a few inches of the joists and carry the pipes horizontally under the joists. I would get the same total elevation by this plan as with a low casing and pipes inclined, but the elevation in the casing would be more efficient than in the pipes, because freer from friction.

But in practice I always use a flat-topped casing and take the pipes off the top because in this way I can make straight lines from furnace to register boxes and foot-pieces, something it is rarely possible to do where you take your pipes from the side of the casing.

By running the leader pipes horizontally and close to the joists you leave plenty of head room in the cellar, if it is of reasonable depth, and they who manage the furnace or use the cellar will rise up and call you blessed.

As in this statement I am flying in the face of all tradition and precedent, I feel that I must back my assertion with a practical example.

Last year in putting in a large job I was compelled, in order to reach a certain room, to carry the air through 88 feet of pipe. Sixty-nine feet of this pipe was horizontal and 19 feet perpendicular. The lay-out was as follows:

I started with a 22-inch pipe, which I carried 5 feet perpendicularly up from casing top. Then a 22-inch 90-degree elbow.

Then 5 feet horizontally to the right. Then another 22-inch 90-degree elbow. Then 42 feet horizontally through a long hallway and out into a "Social Room." Here the 22-inch line ended and the pipe was capped. A few feet before the end I tapped this line with a 9-inch round pipe which heated two rooms in the second story and a 3½ by 12 inch pipe which heated one room on first floor. Close to the end of the 22-inch line I put in a 16-inch tee collar for a 16 by 20 inch register on first floor. In the cap on end of the 22-inch pipe I put a 9-inch collar; on this a 9-inch 90-degree elbow, with 6 feet of 9-inch pipe running horizontally to the left, where by a reducer and 8-inch round elbow I entered a perpendicular 8-inch round stack 12 feet high. This entered the bottom of an 8 by 10 inch square pipe which ran 16 feet to the right horizontally between the joints. The end of this pipe was closed, and I cut into the top a 3½ by 14 inch pipe with a 12 by 15 inch register just above the baseboard.

The long run of 22-inch pipe being all exposed was leveled with a spirit level. You will notice that in addition to the 69 feet of absolutely horizontally pipe I had six 90-degree elbows, not counting the change in direction of air made as it came through the register.

You will notice also that the 16 by 20 inch first floor register was at the end of a 47-foot line of absolutely horizontal pipe.

In laying out this job I made the following calculations:

1. That the 5-foot rise from the top of the furnace would give sufficient force to carry the air to the end of the 22-inch horizontal line.

2. That as the capacity of the 22-inch line was considerably in excess of that of the three tappings, that the momentum of the air would, when it struck the closed end, drive a considerable amount around the 9-inch elbow, and through the 9-inch horizontal pipe, on the principle of the hydraulic ram.

3. That the 8-inch perpendicular pipe would take care of itself and give the air a good push to start it through the 16 feet of 8 by 10 feet horizontal pipe.

4. That by giving this 8 by 10 inch horizontal pipe a capacity 60 per cent. greater than that of the riser by which it was fed I would make up for the loss of velocity.

All the five registers on this system worked well, and equally well, and none better than the one at the end of 88 feet of pipe.

In my own justification I must say that I did not in this case send the air around Robin Hood's barn and back again simply to give it exercise, but because in this case the line followed was the most direct which the construction of the building permitted.

I could give plenty of other instances, and in fact every job I put in is an instance.

I freely admit that if by the use of "pitch" angles can be *materially* reduced or distances *materially* shortened there is an advantage, but claim it is due to reduction of angles and distance, and that this will rarely justify spoiling the head room in a basement.

But my time and your patience would fail should I attempt to give all the fads and fallacies which in my opinion have been connected with hot-air heating. The business has been far too largely left to unscientific men. Every man who has ever lived in a furnace-heated house thinks he knows all about heating with hot air. Every man who can handle a hammer and pair of snips thinks he is competent to put in a furnace. The popular impression has been that science and skill were not needed, and if the house were not heated it was the fault of the furnace or the system.

We are as yet but in the infancy of the business. Sufficient data have not yet been obtained to reduce it to an exact science. In fact, as yet it can hardly be called a science at all. It is not strange that many believe that cheapness in first cost is the only thing the hot-air system has to commend it, and that cheapness in first cost is the only thing to be considered in having a hot-air plant installed.

DISCUSSION.

Mr. A. O. Jones: Mr. Chairman, I would like to ask Mr. Thompson if carrying the warm air perpendicularly before turning horizontally would not have a tendency to obstruct the flow of the air similar to a square elbow; would it not in his estimation be better, and would not the air flow more readily if the pipe were given a pitch from the outlet at the furnace to the entrance of the register or the bottom of the perpendicular wall pipe? Would not a gradual slant be better in his estimation than the short turn?

Mr. Thompson: I concede that if by pitch you could ma-

terially reduce angles it is an advantage; but the advantage is in the reduction of the angle and not in the pitch. Now you take the average case: you have a 15-foot leader pipe, you start that one foot below the ceiling and run it 15 feet long. Where I start 1 inch below the ceiling, 1 foot in 15 feet is all you can do. You have an angle that is so near 90 degrees that the air is not able to find out the difference. Of course I would not use a two-piece elbow on the top pipe. I would use a 3 or 4-piece elbow at the ceiling; but if I had room to do it I would start off the top of the furnace with a 45-degree angle, and then would strike the joist with another 45-degree angle right along the joist, so I could get the pipe up along the joist and out of the way of people's heads.

Mr. Lewis: I had some experience with hot air heating and I agree with Mr. Thompson. In a very large church the supply flue for the auditorium led straight up from the furnaces about 60 feet and then went horizontally about 100 feet and came in at the centre of the dome. There was to have been a fan put in. Before the fan was installed we found the church would heat by gravity. The air got started up the flue and, after reaching the top, the 100 feet of horizontal duct was not sufficient to kill its velocity. It went over and came in at the top of the church, which heated by gravity perfectly. I agree with Mr. Thompson that it is better to get the direct vertical rise in question, and that he had a better chance to make that job work all right by getting the rise before the long run.

Mr. Connolly: I have listened with a great deal of pleasure and interest to Mr. Thompson's paper, which he has christened "Fads and Fallacies in Hot Air Heating," and I would like to add "Follies and Fancies" also. There seems to be so much in the paper that is against all known rules—I do not doubt his experience at all. One of the things that strikes me very forcibly is that he states it is a fad to set the furnace beneath the northwest corner of the house, and that the air in the pipes does not know and does not care which way the wind is blowing. Then he tells us to set the furnace where you can reach all the rooms with the shortest pipes and fewest angles. In other parts of the paper he states that he rises up five feet and then goes off 42 feet horizontally and runs through a long hallway into the social room. The warmth of that social room

must be terrific to make that pipe work. He does not say a word about the cold air boxes. I would like to have him explain something to us about them, and what proportion he makes the boxes in order to do this wonderful work. I do take exceptions strongly to the following statement: "It makes no difference in this respect whether the air is heated by contact with the iron in the furnace or the iron in the radiator or the iron in a stove." It certainly does make a difference where cold air is blowing on the fire pot in a brick-set furnace, when the fire of the furnace is being forced and the fire pot is heated from 600 to 800 degrees.

Mr. Thompson: The point is on the question of the dryness of the air, is it not?

Mr. Connolly: You say it does not make any difference?

Mr. Thompson: If you put cold air against a red hot fire box and heat it to 600 degrees that air at 600 degrees will have a greater absorptive power of moisture than if the air was heated to 200 degrees. But that air at 600 degrees is not heating the house at that temperature; it is mixed with cold air and comes down to about 140 to 200 degrees, with the temperature of the air. It is, of course, the temperature of the air delivered to the room, and not the temperature which it has been heated up to. If you heat air to 1,000 degrees it has greater capacity for moisture than at 150 degrees; but you do not get the moisture out of that air by heating the air; so that, after all, it is a question of the absorptive power of air and not a question of temperature. In the matter of cold air boxes, I always give an extra liberal supply. My rule, so far as I have a rule, is rather contrary to the standard rule. I aim to give about 10 per cent. more cold air supply than the total area of the pipes taken off the furnace. With regard to the social room, this 22-inch line, I admit this was a very crooked line—in fact, I never liked it. I liked it so little that I went to the trustees of the church and told them about it, but they would not let me go where I wanted to—I wanted to cut joists; they refused to allow me to do it, and I said, "I will do all I can, I will give you all the knowledge I have, I will do all I can to heat that room; I *think* I can heat it, but you have got to take your own chances." The 22-inch line ran through this hallway out into the social room, and there

was no heat in the social room most of the time. This social room had its own heating apparatus; it was not heated at that time at all; we had to go through this hallway out to the left of the social room to get floor space. I had to go alongside of the column there wherever the wall boxed it in.

Mr. Davis: I would like to ask Mr. Thompson how he exhausted the air from these rooms that he heated? What he did to cause circulation there? I would like to ask further, in bringing air into large rooms, if he thinks the proper way to heat the room is to bring air in at the ceiling? We have a good many installations of that character, and they have been universally successful.

Mr. Thompson: I had no chance at this job to bring the air in at the ceiling. It was a large church, and everything was laid out for decorative purposes; but there was a system for withdrawing air from the room to allow ventilating, a stack—I forget the measurements now; but owing to the difficulty in reaching that stack, I got them to allow me to use a place in the front part of the church, as another stack. Along the rear of the church, through that social room, I carried a 20-inch line of galvanized pipe back to connect with this ventilating stack, and connected that with the floor registers from every room that was to be ventilated. There were certain portions of the rooms upstairs and downstairs, rooms that were small and only temporarily used, and I only ventilated one or two of them; but in all the other rooms we connected one of those rooms with the ventilating stack.

Mr. Davis: I would like to ask if the ventilating stack would have the same capacity as the registers?

Mr. Thompson: It would not. We usually calculate on having it about one-half to two-thirds. If you make the ventilating apparatus just the same capacity as the heating apparatus the tendency would be to draw in cold air. It depends upon the size of the building. I run from 50 to 80 per cent. of the capacity of the supply pipe.

Mr. Weinshank: Mr. Thompson says on page 284: "I examined the furnaces and found they were working up to the limit, and that the three could deliver about 1,400 cubic feet of air per minute." How does he know he got 1,400 cubic feet of air per minute? Did he measure it? How has he

measured it? It is my experience in air deliveries that we are to-day yet at a loss to measure accurately air velocities, and there is yet an instrument to be developed or invented that will tell us the velocities of air delivered. If Mr. Thompson has had an opportunity of measuring air and telling the exact amount of air he can deliver, I would like to know the name of apparatus used.

Mr. Thompson: I think if the gentleman will look at the copy he will see I state in all these cases "about." I always put "about" in the question of the measurement of air. I have no method different or better than an anemometer, which is not strictly reliable. I reckon up the feet area of the opening, and I realize there are no two points in the pipes that deliver air with the same velocity, and it is always "about." But I do know this: If I have a 16-inch pipe which shows in the centre a velocity of 200 feet, if I take that off and put in a 28-inch pipe which shows in the centre a velocity of 400 feet, I am getting more in the last job than I was in the first.

Mr. Weinshank: May I ask another question? On page 288 Mr. Thompson states that the way he reduces the moisture or the temperature of the air which passes over the furnace is by admitting a *lot* of cold air, never stating the ratio of the cold air to the hot air. But admitting that the *lot* is sufficient, is it not true that the hot air, at a temperature of 600, has absorbed nearly all the moisture of this *lot* of cold air that has been admitted, and reduced the temperature of the hot air? And is it not true that the air which then enters the room is dry?

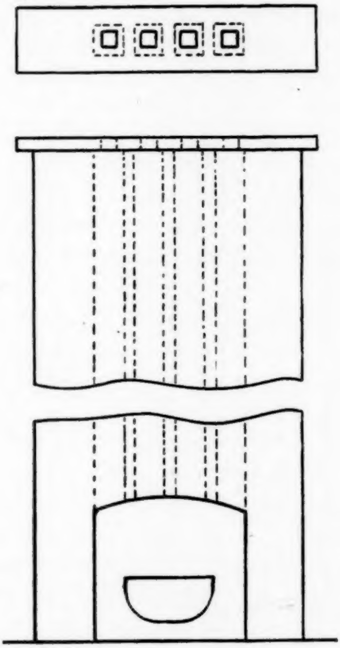
Mr. Thompson: The hot air at 600 has the drying capacity, that is, absorptive power, that is all. As soon as the hot air at 600 is reduced to 70 it has no more absorptive power than air which has not been heated to 600; the increased capacity is lost as soon as the air becomes cool.

Mr. Donnelly: Is it Mr. Thompson's usual practice to make registers larger in area than the pipe delivering to them? I notice he has a 3½-inch by 14-inch pipe and puts in a 12 by 15-inch register. Has he ever heard of the fallacy of making all registers considerably smaller in area than the pipes leading to them?

Mr. Thompson: I never heard of that plan. I have always preferred to have the registers just a little bit larger, but do

not consider it absolutely necessary. In this particular case I used a large register because I had so many difficulties to overcome that I wanted to make it just as easy as possible for the air to get out.

Mr. Donnelly: The greater part of my hot air experience has been gained in discussing the subject with my friends and in working up arguments that would help sell steam apparatus by showing how much better it was than hot air.



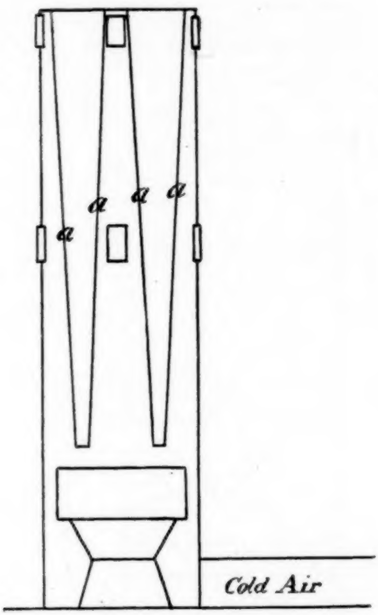
MR. DONNELLY'S SKETCH. FIG. I.

Formerly we thought that we made a very great success if we convinced our man, but to-day I am willing to concede that hot air has many merits and might have more if it were handled with more care.

There must be a cause for the wide difference in results in hot air work, and it lies somewhat in the general theory of conveying any fluid through a pipe; that the delivery outlet should be smaller than the pipe.

It has generally been considered impossible to make a fire draw when connected to two or more flues; even when they are the same height and size. Smoke will usually go up one flue and air come down the other. This problem is exactly the same in hot air heating, with the additional disadvantage that the flues are of different sizes, lengths and heights.

Let us consider the problem of making an open fireplace draw through several flues as shown in Fig. 1. This may be



MR. DONNELLY'S SKETCH. FIG. 2.

accomplished by restricting the outlet of the flue, with the cap stone as shown.

Applying the same theory to a hot air heating plant and illustrating it by Fig. 2, we have a system which we will first consider with one very large flue. It is very apparent that we would get a positive delivery of air from each of the registers, and the quantity would not depend on the size of the flue but on the heating capacity of the furnace and the size of the registers, as there would be a positive pressure on each

outlet. Of course the flue is drawn unnecessarily large. We will cut out the portions as shown by the lines *a*, and then if we still leave the proper area we will have a pressure on each outlet and a positive delivery from each. We may then run the pipes horizontally, and, as Mr. Thompson says, we need not be particular about the pitch.

This method would result in the expenditure of more money on tin pipes, but tin is cheap, and less on registers, which cost more.

One other point. Just as the cold air box must be large enough to permit of a pressure being produced on each register outlet, so the registers must be large enough to deliver sufficient air to produce a pressure on the ventilation and air leakage outlets from the building.

If there is too much ventilation or air leakage the building cannot be heated by a hot air furnace. An eight-room house with six open fireplaces is an impossibility. Cold air will enter through the leakage openings on the windward side and warm air will go out on the leeward side.

Mr. Schaffer: Was there any other pipe on the furnace Mr. Thompson described, except the 22-inch pipe?

Mr. Thompson: There were about ten pipes, from 36 inches to 10 inches.

Mr. Schaffer: Did they all rise the same?

Mr. Thompson: No; it was a complicated job. The 36-inch pipe was perfectly straight up to the floor of the main auditorium. Then there were two 12-inch pipes that ran a distance of 45 feet, according to the approved plan, and heated two vestibules on the floor of the auditorium.

Mr. Schaffer: Did the long 36-inch pipe running straight to the auditorium work?

Mr. Thompson: Yes, it worked very well.

Professor Kinealy: How did Mr. Thompson derive the rule for determining the number of feet of air per minute?

Mr. Thompson: Various tables have given me a rule, which I find in practice usually works out right, of allowing 38 B.T.U. per hour of each square foot of wall surface. Take this figure 38, multiply it by the square feet of your house and divide it by 2, and then reduce that to the number of cubic feet of air at 70 degrees and 55-100ths heat units per

cubic feet, and you will get at this just about as I do; that was the route which I followed. I will say one thing—that rule is liberal, it does not give the exact amount, it gives a little more, but it is a very simple rule to get at. I take the extreme length of the building, I pay no attention to the angles, the extreme length and extreme width, adding it together and multiplying it by the height.

Mr. Kinealy: You pay no attention to windows; this is average conditions?

Mr. Thompson: Simply for the average house; if you have a complicated problem like that church, we usually make some allowance for windows; if you have windows 16 by 20 then that is different. But take the average residence, windows do not cut much figure; I have found that rule works nicely and is a very safe rule.

Mr. Kinealy: On page 288 you say: "A house heated by hot air needs no ventilation but what the furnace gives it." That, of course, is supposing that the furnace takes all the air from the outside. Would that statement apply if the furnace took the air from a cold hall?

Mr. Thompson: Not if the furnace took all the air from the inside. I would say that my calculations are based on the furnace taking the air from the outside. That brings up a little fad of mine; I notice what some scientific investigations show about carbon dioxide in the air, that it is not the carbon dioxide that makes the air bad. I have heard of some experiments in which it was carried up to 100 times beyond the standard and was found not to be injurious. A chemist tells about having his laboratory filled with carbon dioxide, and yet he felt no ill effect. It is the organic matter that is bad. Here is something I don't know at all, it is one of the things that some of you may know about and I would like to have your information in regard to it: I believe the organic matter in the air is what makes the air poisonous, and that the carbon dioxide you can probably neglect. You take a stream of polluted water and let that stream run exposed to the air, and the motion of the water and the exposure to the air purifies the water by oxidation of the organic matter in it. There is a process of purification going on in the atmosphere all the time (this is simply a germ idea), or else the air of this world

would be so foul nobody could live in it. I believe the organic matter is gradually oxidized. Now if you heat your house with a hot air furnace and provide for a rapid and vigorous circulation, are you not going, to a certain extent, to accomplish that same thing, the oxidation of the organic matter and partial purification of the air, so that there may not be the necessity, if you get a large volume of air, at a high velocity, for the 25 cubic feet a minute for each inhabitant? Of course, take the average house, you could allow more than 25 cubic feet a minute. I see an English engineer has figured out that in the average house with plastered walls, there being a natural exhaust and inflow from the walls and around the windows, that the air in that house is changed about once an hour simply by the leakage. If that is the case, we do not need to introduce much outside air to get pure air in the house. But I do not lay that down as a rule.

Mr. Kinealy: Then, Mr. Thompson, it is not the impure gas in the air but it is the organic matter that is in the air?

Mr. Thompson: That I believe is pretty well shown.

Mr. Kinealy: So that one may take no air from the outside at all and yet by recirculating the air in the house maintain a higher degree of purity in the air in the house than if he took the air outside altogether, because the air taken from the outside will contain dust, manure, and other organic matter, is that it?

Mr. Thompson: I don't want to lay that down as my doctrine. That is the doctrine I am edging toward.

Mr. Kinealy: Don't your doctrine lead up to that?

Mr. Thompson: That is what I say, I am edging toward that doctrine.

Mr. Kinealy: So I thought. That explains why it is that the physician sends his patient to Colorado or Arizona rather than keep him in a house supplied with air taken from the outside. If the physician would prescribe that the patient install in his house an apparatus for freeing the air of organic matter or washing and cleaning it, an apparatus that would at the same time free the air of organic matter, it might be that the patient would be better off than if he were sent to Colorado or Arizona?

Mr. Thompson: I believe he would.

Mr. Kinealy: I think so myself. In other words we ought to install air purifying apparatus.

Mr. Donnelly: I think, according to Professor Kinealy's idea, that some of the modern jails would be a good place to put some of these people in because they are purifying the air in there and taking care of it; but I don't want to be shut up in a house, I want to get out of doors, even if I have to die; I had rather die outdoors than live always in a house. I notice this rule of Mr. Thompson's does not take the roof into consideration.

Mr. Thompson: No.

Mr. Donnelly: The roof is usually pretty leaky. There is no doubt but that most roofs leak more or less. Taking a house 20 x 40 I find there is probably four or five changes of air an hour normally.

Mr. Thompson: Yes.

Mr. Donnelly: There is in an average house usually as many as one or two ventilating flues, and sometimes there is also an open fireplace.

Mr. Thompson: The average house leaks very much.

Mr. Donnelly: What is the proportion between the leakage and ventilation between the flues?

Mr. Thompson: The average eight-room house seems to be the standard type generally built, and unless they are extremely particular about the building of it I can pump about 1,200 cubic feet of air per minute into a house of that character and it will all get out in some way.

Mr. Donnelly: Without any ventilating devices?

Mr. Thompson: Yes. The average house leaks about 1,200 cubic feet a minute. Of course sometimes you might get a house that is fixed up with papered walls and flashed under the sills, and everything tight, in which case you would get an air-bound house; but nine out of ten will leak.

Mr. Jones: I have come across a great many houses with a different number of rooms, where certain of these rooms could not be heated without ventilation. I have in mind a residence in Rochester, Minn., where I was called to locate the difficulty in heating one particular room. I found that the room had been provided with a ventilator, but the occupants of the house got the idea that cold air was coming in through this ven-

tilator, and they closed it. All that I did was to remove a large rug from the ventilator which was placed in the floor with connection under the floor to a vent flue, and I found that the room was properly and thoroughly heated afterwards. A pipe leading from the furnace to the register or wall pipe gives better satisfaction if there is a gradual slant from the furnace to the outlet.

Mr. Thompson: In the matter of air from a furnace-heated house the furnace gets a great deal of blame that does not belong to it. Everyone knows that the average furnace-heated house is stuffy. Because the house is overheated? No. It is caused by the dirt that falls down into the furnace through floor registers. I have taken down old furnaces where the ashes, dirt and filth on the top were two and a half to three inches in depth. Now, that stuff lies there and smoulders, smokes and smells. If either wall registers that open from the wall are used or the bottom of the register boxes is provided with a "T" with a cap on the bottom that can be taken out and the box cleaned instead of an elbow, this difficulty will be overcome. If the furnace is covered with a quantity of organic matter foul air will be the result.

Mr. Jones: The question has been asked as to how to determine the amount of air necessary for a given room. I would quote a rule that I have followed with success for determining the area of the air supply. "The exposed wall surface less doors and windows, divided by the thickness of the walls—in no case less than 10—added to the actual glass surface, the total multiplied by 75, and this added to the cubic contents and the whole multiplied by .013 gives the area in square inches of the warm air conductors." I have applied that rule to rooms in churches or auditoriums, and in residences for bathrooms, bedrooms, living rooms, and almost every kind of room, and I know of no case where it has failed.

Professor Kinealy: First and second floors the same?

Mr. Jones: The velocity of the air in the conductor from the furnace to the first-floor room, with an elevation of one inch in 12, is estimated at 100 feet a minute; and the velocity in perpendicular conductors is from 200 to 300, or on an average 250. I would recommend a conductor to the second

floor rooms to be half the area of the conductor to the first floor rooms.

Professor Kinealy: You mean by the conductor the stack or pipe?

Mr. Jones: If it is either the second or third floor it would be a perpendicular conductor, or what is known as a wall pipe or stack. This is for zero weather and for each degree below zero add one per cent. of the area of your pipe. The same rule holds good from the furnace to the bottom of the riser, taking into consideration the increased velocity in the perpendicular pipe. Now, as to the cold air supply, I have always used and recommended an air duct or air supply with an area of 90 per cent. of the combined area of the warm air pipes. That is allowing 10 per cent. for expansion. It is estimated that air will expand from zero to 175 degrees above zero 25 per cent., and from 70, the temperature at which it enters the upper outlet for inside circulation, the expansion is not usually over 10 per cent.

Mr. Widdicombe: I would like to ask Mr. Thompson if it is not true that in drying lumber you absorb the hygroscopic moisture by continually passing air of a low temperature over the wood; and is it not the great objection to hot air that you send hundreds of cubic feet of air into the room per minute which is absorbing a great deal of the hygroscopic moisture in the room?

Mr. Thompson: I think that is a fact; an extra circulation of the air will take out more moisture in the room. It is not a fact any more with the hot air than with any other system if you use the same quantity of air. With indirect radiation you have a certain amount of ventilation with it, and if you get the same ventilation, you will still get the same drying power. But I am of the opinion that in hot air heating with outside air we do use an excessive and unnecessary amount of air in private residences. You don't get too much in school rooms and churches, but in private residences we do use a great deal more than is necessary.

Mr. Widdicombe: Is it not true in indirect steam heating that the air will leave the registers somewhere around 200?

Mr. Thompson: I always estimate the temperature at 140.

CLXVI.

WALL RADIATORS *VS.* LONG PIPE COILS.

BY J. A. DONNELLY.

(Member of the Society.)

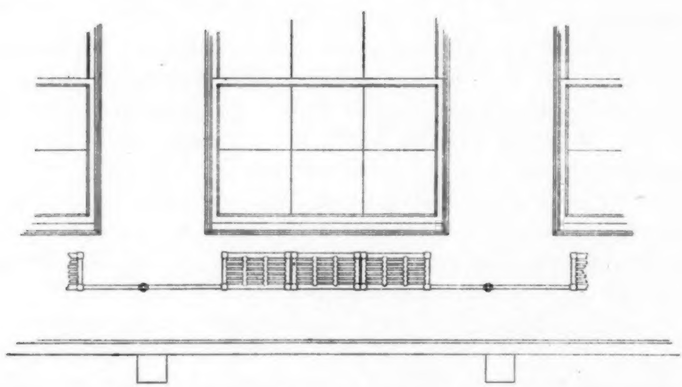
Although the use of wall radiators in place of pipe coils has been advocated quite broadly by manufacturers, they have been mainly used only in place of short coils. A prejudice seems to exist against the use of long radiators and coils that is not warranted by the facts in two-pipe steam work.

It is the purpose of this paper to consider their use for heating buildings in which long coils are usually employed—such, for instance, as factory buildings of ordinary construction. Assume for this purpose a building 150 by 60 by 12 feet, with the usual amount of glass surface. Such a building will require coils of 6 1¼-inch pipes on all outside walls except the top floor, which will need from one-third to one-half more. Not less than four coils would usually be erected on each floor, and thus they would each be about 100 feet long.

The limit in length of a coil, considering only the proper circulation of steam through it, would be that each individual pipe should not have in itself more surface than good practice would warrant putting on that size pipe. Thus, a coil made of 1-inch pipe 120 feet long would have 40 square feet, and one of 1¼-inch pipe 172 feet long would have 75 square feet of heating surface in each pipe, and this would therefore be about the limit of length if that were the only factor. The easy control of the proper heating of each floor should, however, be taken into consideration; and this of itself seldom warrants coils exceeding 100 feet in length, and therefore this has usually been considered as the limit of good practice.

In regard to the comparative lengths of time required in the heating of long and short coils and large and small radiators, some misconception seems to exist, and a preference is usually expressed in favor of short coils and small radiators.

It may ordinarily be considered that a 100-square foot radiator or coil will require the introduction of about two cubic feet of steam to displace the air contained in it and about four hundred cubic feet to supply the heat units absorbed by the specific heat of the iron in the initial heating. It will thus be seen that the displacing of the air may be considered a negligible quantity, and that if the effective area of the supply pipes are directly proportional to the sizes that a large radiating unit will heat as quickly as a small one. The same fact will hold as between a long and a short coil, if the length is within proper limits, as the time required for heating is governed to such a large extent by the quantity of steam required and affected to such a small extent by the distance the steam must travel.



Wall radiators to be used in place of long pipe coils are usually made up in groups of several sections, and the several groups may be connected with one connection at the bottom or with a connection at both top and bottom, as they work equally well either way. The limit of the length will then be the amount of radiation that the passage through the radiators is capable of properly supplying; thus, for wall radiators to be used in place of a six-branch 1¼-inch pipe coil 100 feet long, 260 square feet of surface, two 1½ or one 2-inch connection should be used.

Very many factories are built with 10-foot bays and windows about 7 feet wide, and the accompanying table has been prepared to show the number and size of wall-radiator sections that would be required to give the same amount of rated surface as

that which is contained in the pipe coils in the corresponding columns.

Thus, to take the place of six 1¼-inch pipes three 9-foot sections would be required in each bay. This would make a group 6 feet long and 13 inches high if the sections were placed on their sides—probably the preferable way—or 3 feet 3 inches long and 2 feet high if the sections were placed on their ends, which might be desirable if the wall space was to be left as free as possible of heating pipes.

This substitution of wall radiators for pipe coils, aside from any argument as to the relative efficiency of each under ordinary conditions or under the conditions of special tests, is many times preferred by the factory designer, and should be by the heating engineer, as it concentrates the heating surfaces under the windows and leaves a larger amount of wall surface free for other purposes, both of which are very desirable features. The total amount of wall surface occupied by the wall radiation is also less than one-half that occupied by the pipe coils.

Where ceilings are extremely high, or glass surfaces in windows or skylights are unusually large, it is often possible to use wall radiation when it is impossible to get enough surface in pipe coils under windows of the usual factory height of 36 inches.

RELATIVE SURFACE IN PIPE COILS AND WALL RADIATORS.

Size and Number of Pipes in Coils 10 Feet Long.								Size and Number of Radiator Sections.		
1-inch.		1¼-inch.		1½-inch.		2-inch.				
No. of Pipes.	Sq. feet.	No. of Pipes.	Sq. feet.	No. of Pipes.	Sq. feet.	No. of Pipes.	Sq. feet.	No. of Sec.	Surface in each Section.	Total Surface. Sq. feet.
3	10			2	10			2	5 feet	10
4	13⅓	3	13			2	12½	2	6 "	12
5	16⅔			3	15			3	5 "	15
		4	17⅓			3	19	3	6 "	18
6	20	5	21⅔	4	20			3	7 "	21
7	23⅓			5	25	4	25	4	6 "	24
8	26⅔	6	26					3	9 "	27
9	30	7	30⅓	5	30	5	31	5	6 " on end	30
10	33⅓	8	34⅔	7	35			5	7 " " "	35
11	36⅔	9	39			6	37½	4	9 " " "	36
12	40	10	43	8	40			6	7 " " "	42
14	46⅔			9	45	6	44	5	9 " " "	45
15	50	11	47⅔	10	50	8	50	7	7 " " "	49
16	53⅓	12	52	11	56	9	56	6	9 " " "	54
18	60	14	60⅔	12	60	10	62½	7	9 " " "	63
22	73⅓	17	74	14	70	12	75	8	9 " " "	72

The most effective way of making the pipe connections between the several groups is by using a good grade of unions, as the pipes and radiator tappings may not be straight and the unions allow in some measure for correcting this. They may be connected by right and left threads, but it is a difficult connection to make. Probably an improvement in this respect would be effected by furnishing special glands with a round face upon the end that is to be bolted to the radiators and a pipe thread upon the other end.

In regard to the comparative cost, the wall radiators erected in place usually cost less than the coils, though this is affected greatly by the variance in the cost of pipe and labor.

DISCUSSION.

Mr. Kerr: Mr. Donnelly concludes with the statement that "In regard to the comparative cost, the wall radiators erected in place usually cost less than the coils, though this is affected a great deal by the difference in the cost of the pipe and labor."

If Mr. Donnelly could install coils at the same price, would he use wall radiators in preference to coils?

Mr. Donnelly: There are advantages in the use of wall radiators, but it has to be decided by the engineer to a great extent, and in some cases by the customer. If it was left entirely to my judgment, I would prefer to group the radiation under the windows and would rather use wall radiators on account of their surface being in that location. The cost of maintenance would probably be less. Then, under ordinary conditions, the air removal is better; that is, it is apparently easier to remove the air from wall radiators than from pipe coils. The difficulty of taking care of the expansion in either case is about the same. The appearance of wall radiation is somewhat better. It is a great deal a matter of prejudice, but the advantage is in favor of wall radiators at the same price.

Mr. Wolfe: Has Mr. Donnelly ever made an actual test of the condensation of water per square foot in each?

Mr. Donnelly: I have not. I have rated them in accordance with my experience. Pipe coils 300 B.T.U. per square foot per hour, wall radiators at 290 B.T.U. In some cases you may get a little more out of your wall radiators than out of coils, although

there are cases where you would get more out of your coils per square foot than out of your radiators. It is a question of maintaining the full efficiency of the air removal. The difference in condensation has been tested, and some authorities rate wall radiators as a great deal more efficient than coils. If that is true, we should endeavor to increase the efficiency of the coil. A single 1-inch pipe is rated at 400 B.T.U. per square foot per hour, and pipe coils at 300. If that is true, it is on account of the poor air removal from the pipe coils. Cutting down the efficiency 25 per cent. is too big a drop.

Mr. Harvey: In heating an ordinary factory would you not consider a 1¼-inch coil, 25 feet long, to be more economical for a large room than cast-iron section radiators?

Mr. Donnelly: More economical for heating the room?

Mr. Harvey: Yes; owing to the better distribution of the heat.

Mr. Donnelly: The method described in my paper gives a better distribution of heat than coils 25 feet long, because just the surface needed for heating is laid out under the windows.

Mr. Harvey: But the coils would be under the windows also.

Mr. Donnelly: Yes; and they would also be along the blank wall space between the windows if they are 25 feet long.

Mr. Harvey: In heating these wall spaces the wall would absorb a certain amount of heat and give it out afterwards, would it not?

Mr. Donnelly: Yes; the difference in the amount of steam used would not be a factor in either case. It might be a very small percentage. The heating of a room with radiation under the windows is a little more effective; it is a little more pleasant to the workers and occupants of the room that have benches and have to work near the windows. There is a better distribution of heat, and the cold drafts from the windows will not affect the occupants quite as much.

CLXVII.

AN IMPROVED APPLICATION OF HOT-AIR HEATING.

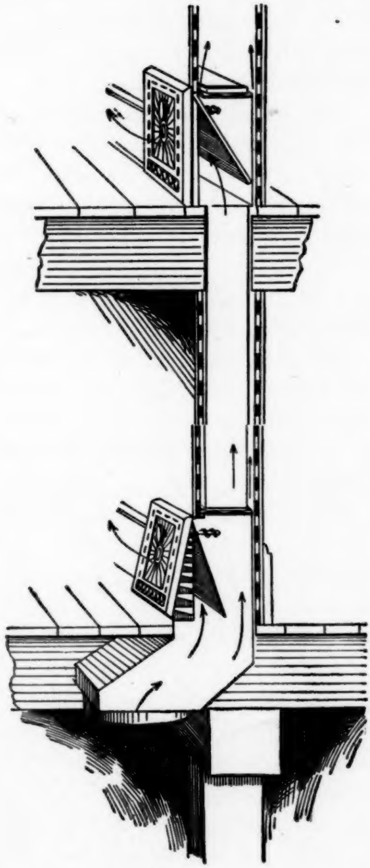
BY A. O. JONES.

(Member of the Society.)

An improved warm-air heating system which has rendered modern furnace work less complicated—an ever increasing number of practical and perfectly working heating plans—make it possible to describe a thoroughly tested and practical heating system; a system insuring the greatest amount of heat from a given quantity of fuel, and one enabling the operator to control the supply of warm air, directing it at will into the rooms to be heated, securing ventilation at a small expense and reducing the cost of installing warm-air furnaces, at the same time increasing their efficiency, is, in the writer's estimation, and in the face of rapidly disappearing prejudices, a system worthy of universal adoption.

The system under consideration differs from those in common use in that ventilation is secured in all rooms and the basement is not filled with warm-air pipes, but consists in the placing of any modern warm-air furnace of the correct size in an ordinary basement of reasonable height. The furnace is to be centrally located and supplied with fresh air in amount equal to at least 90 per cent. of the combined area of the basement pipes, and the warm-air chamber connected, by one-half the number of warm-air pipes ordinarily used, to improved warm-air registers placed in the wall of each room on the first floor, with a wall pipe continuing from the top of each register box to the rooms on the second floor, using for heating each two rooms—one on the first floor and one on the second—a basement pipe with capacity equal to the capacity of two pipes necessary for heating these two rooms separately. The manner of connecting the wall pipe to the top of the improved side wall register is shown in the illustration.

The advantages to be gained are that ventilation is secured in all the rooms, as the registers should be provided with a double metal box, arranged with an air space between the inner and outer casing, and a ventilating opening, where air is drawn



out of the rooms being heated and is conducted through the air space upwards, around the wall pipe—if single wall pipes are used—or through the space between the two casings of a double wall pipe when the latter are used.

The heat of the wall pipe causing an upward current insures a rapid movement of the foul air to a point in the attic directly

above the registers, where it should be conducted through vent pipes to a chimney flue not used for any other purpose.

It will be seen that cellar air—as ordinarily used for protection when double wall pipes are used—is not allowed to enter the space between the two casings of the wall pipe, but, instead, air is drawn from the rooms; therefore, coal dust and fine ashes are not found escaping through the registers, as is sometimes the case with the systems that have been in use before the introduction of this system, which has been adopted by a great many furnace dealers who testify to the practicability of the system described.

The advantages of being able to utilize all of the warm air from the furnace in the first floor rooms when the second floor rooms are not in use should not be overlooked, for as is well known—with the old plan of installation—the closing of the second floor registers or the dampers in the pipes leading to the second floor registers, does not increase the amount of air delivered to the first floor rooms, but simply causes the air to be overheated, which is very objectionable—often giving rise to the argument which is advanced regarding vitiated air. While with this improved system the full amount of the air supply is constantly moving, and when the second floor rooms are not in use the fire in the furnace must necessarily be checked and a larger amount of air is supplied at a lower temperature.

When the second floor rooms are in use the increased velocity of the air in the perpendicular or wall pipes makes it possible to heat rooms on the first floor located some distance from the furnace, which is difficult without the assistance of the suction caused by the wall pipe.

The reduced number of warm-air pipes in the basement makes it possible to connect the larger warm-air conductor at a point on the bonnet of the casings where it can run straight to the register. This makes angles unnecessary, excepting in rare cases, and as a straight line is the shortest distance between two given points, the least possible amount of piping is used with very few angles; therefore, the friction and radiation is reduced to a minimum, which means cooler basements and warmer living rooms, to say nothing of the reduction of cost in installation.

This system, therefore, renders modern furnace work less complicated, insures perfectly working warm-air heating plants, se-

curing the greatest possible amount of warm air from a given quantity of fuel, reduces the cost of installing furnaces, and makes failure almost impossible.

DISCUSSION.

Mr. Donnelly: Mr. President, I would like to ask Mr. Jones whether he uses any dampers in the hot-air pipes leading from the top of the furnace casing to these wall pipes and registers?

Mr. Jones: Yes, sir, the illustrations showed the dampers. I would recommend the use of a damper in each warm air pipe used with the furnace, if for no other purpose than to be able to close the heat off from both downstairs and upstairs rooms if it were found necessary to do so.

The Secretary: Mr. Jones, did you say these dampers are for regulating the amount of air? I notice in this illustration you can drop this damper and can open the registers on both floors, can regulate both the first and second floors, thereby regulating the openings there so that you can balance one room against the other. Is it customary to use these dampers in regulating the air, and do you find that you can control the distribution of air through the house by regulating the dampers on top of the furnace?

Mr. Jones: The damper in the basement pipe is really not necessary, except where two rooms are not used, or once in a great while one is used, as when one set of rooms, say one downstairs and one up, might be heating faster or better than another set of rooms in another side of the house; the advantage of having dampers would be that you could control the supply that went into the two sets of rooms, from one side of the house to the other, although ordinarily it is not necessary.

Mr. Chew: I think that the partition pipe coming in to furnace heating has been a detriment to it. The pipe does not give sufficient area to send through the volume of air at low temperature to heat a room; and consequently the partition pipe necessitates overheating the furnace. I am of the opinion that the man who invented the first of these new type side wall registers is entitled to the thanks of mankind, because such a register makes it possible for the area of the duct to the register in the first floor rooms to be of twice the area in a more natural form than

it is in others, and we all know that the first floor rooms are the hardest rooms to heat. I think Mr. Jones has not brought that out in his paper. The present commercial age has demanded a cheap furnace system. They put these scant partition flues in a house, and it doesn't make any difference whether it is a house worth $2,500 or $25,000 that is to be heated, the contractor or the architect will put in partition flues. The new type side wall registers has made it possible to give the proper area to the flues to the first floor rooms and to properly heat them. Another point I wish to bring out is that instead of having floor registers with independent piping to the furnace, with its cost, with these new type registers with enlarged pipes up the side wall one pipe can be made to heat two first floor rooms. The wall pipe leading from the top of this register box to the second floor does not get sufficient velocity to carry away all the air of the first floor; even if there was no flap in the register to interfere with it. The flap in the register permits the quantity of air that goes to the second floor to be regulated or held in the first floor as required, so that I feel that the bad effects of a bad thing may be decidedly reduced through the invention of the register that is brought to our attention in this paper. It is a very positive advantage that the entire area of these large pipes can be made available for first floor rooms. At the January meeting Mr. Frederick Sabin of Philadelphia made some remarks and quoted some figures in reference to furnace heating systems with round risers, which he had installed there. He said that the consumption of fuel with the large round risers letting the air flow through very easy was small as compared with other houses of the same size heated with steam and hot water. Now my point is that this particular register provides for an enlarged base riser which allows ample area through which the warm air can flow, and I am confident that you can heat a building with warm air much better with these new registers than with registers and wall stacks in common use.

NO. CLXVIII.

TOPICAL DISCUSSIONS.

TOPIC NO. I.

"The Comparative Relation Between the Completeness of Air Removal and the Efficiency of Steam Radiators."

DISCUSSION.

Mr. J. A. Donnelly: I have suggested this as a topic for discussion instead of attempting to write a paper upon it for the all-sufficient reason that it is a subject about which I know absolutely nothing. I have searched through all available sources in an endeavor to obtain information upon it from others and have not secured anything that was satisfactory.

I am of the opinion that the varying results that have been obtained by tests upon different styles of radiating surfaces and radiators composed of different materials have been caused, to a greater extent than we have perhaps supposed, by a variation in the completeness of air removal. This may be the correct way to test radiators in order to show the total advantage of one style over another, but it would be interesting to know how much to charge up to this factor and endeavor to correct it by better air removal.

It is probable that there is a difference in the efficiency of radiators circulated upon the one or the two-pipe system by reason of the difference in air removal and perhaps an increased efficiency in the use of the hot water type of radiator when used on steam with the steam connection at the top and the return at the bottom, same or opposite end. There may be a difference between those methods of circulation which employ an air valve upon a loop of the radiator to extract the air and those which have an air valve upon the return, or those which conduct the air down the return to be afterward extracted at a common point of discharge.

The greater efficiency of wall radiation over pipe coils, if it really exists as it seems to do, might be materially changed by a study of this subject which would lead to a better means of air removal from the coils. It is very difficult to get a good air removal from a pipe coil built with headers, and return bend coils have often been preferred because of this. Too high a velocity of entrance to the header causes the steam to skip the first pipe, and this has sometimes led to the use of headers of larger size run than the pipe connections and to the use of some form of baffle plate inside the header. It is also difficult to properly locate the air valve. It is often placed on the top of the return header, where it certainly does not take the air out of the lower pipes. When it is placed upon the return pipe, better results are usually produced, though it very often floods with water in that location. Wherever it is placed it cannot act properly if the coil takes steam from the return end, and on account of the fact that coils are usually built rather long they are very apt to do this.

Certainly a greater efficiency of air removal over the methods now employed, for a type of surface better adapted to correct air removal, would help hot blast radiation.

Air at varying temperatures and pressures has a varying capacity for the absorption of moisture, and steam likewise must have a certain capacity for the absorption of air before materially affecting the efficiency of the radiator. A certain proportion of air we know must be present before it can be detected by a cold spot on the radiator, yet its efficiency may fall materially before this can be done, but until it may be found in this way we usually consider that we have complete air removal.

A vessel consisting of a single body portion, of reasonable area in cross section, with a steam connection at the top and a discharge from the bottom for both water and air, with an admittance of steam at a comparatively low velocity would seem the most favorable for complete air removal. One divided into two body portions with a steam and return connection at the bottom and an air removal some distance above, would seem an unfavorable design.

These two constructions represent, to a large extent, the difference between ordinary loop steam radiators and hot water loop radiators used for steam.

There are two simple and quite exact methods that could be employed to vary the completeness of air removal in tests of this character. One would be to exhaust the air from any type of radiator to a selected fractional amount, by an air pump, close the exhausting connection and admit steam, thus heating the radiator with a known portion of the air it originally contained left in it. The other way would be to use a hot water type of radiator with a steam connection at the top, fill the radiator with water, close the connection, open the return and admit the steam. As the water ran out its place would be taken by the steam and there would be a perfect air removal, if a type of radiator was selected that was free from air pockets above the line of the air valve. By partially filling the radiator with water, tests could be made with varying amounts of air present.

The efficiency of a single horizontal pipe under condensing test in comparison with pipe coils has been shown to be so much superior that the question might be raised if some of this superiority might not be due to better air removal; and if so whether the efficiency of the coil might not be considerably improved by a study of this subject.

Mr. Kinealy: This is a most interesting topic, but it is extremely difficult; in fact, I think it is impossible to give any exact ratio. I have made tests where I have taken the air out of the radiator and created in it a vacuum of 20 inches, then turned on the steam, and determined by a number of very careful tests the amount of condensation per hour with this radiator keeping the outside condition, the condition of the air surrounding the radiator, always the same for the different tests. Then I have taken the same radiator and allowed it to cool down and filled it with air and have created in it a vacuum of 15 inches and determined the condensation after having turned the steam on, the steam pressure being the same in both cases, and the air pressure being the same in both cases. The radiator was in a small box used for a room to which no one could get, and thermometers were rigged up so that they could be swung around to a window and read. There could be no movement of air other than that strictly due to the radiator, no one could walk around the radiator and no air currents from the outside could strike the radiator. I have tested this same radiator with a vacuum of 10 inches, and 5 inches, and 4 inches, and I invariably found

that with the higher initial vacuum, that is with the more perfect air removal, I got the better efficiency or condensation from the radiator. But while it might be a certain amount on one radiator it would not be the same amount on another radiator; that I found by experiment. So that, as I say, I don't think it is possible for us at present to say whether the increase if we start with a vacuum of 20 inches would be 10 per cent. or 5 per cent. over what it would be if we started with no vacuum at all. The exactness with which we free the radiator of air will affect very materially the efficiency of the radiator; I don't think there is any question about that. And there will be times, too, when the radiator is apparently free of air and the radiator will feel hot all over, and yet it will not be completely free of air, all the surface will not be as active as it ought to be.

Mr. Bishop: An efficient radiator is one in which we can get the greatest amount of heat when there is the greatest demand, and one in which the quantity of heat discharged into the room can be controlled by the occupant. The greatest demand for efficiency of a radiator is only about one-fiftieth of a heating season. Engineers should do more to make the heating installations more satisfactory during the forty-nine-fiftieths of the year rather than during the one-fiftieth portion of the year. We should install sufficient radiation to keep a room satisfactorily warm at the minimum outside temperature and then have a means to regulate the admission of steam into the radiator so that it would be equally as satisfactory at other times. During the past three or four years we have made a great many experiments with top-connected radiators, using them with no air vent at all on the radiators, no return valves on the opposite side of a two-pipe system, with the usual small supply pipe of a half an inch in size and with a graduated opening supply valve placed at top of radiator so that with five-ounce pressure constant at the valve it is up to the occupant of the room to determine what portion of the radiator shall be heated. If the day is mild and only one-tenth of the heating capacity of the radiator is needed to keep the room at a temperature of 72 degrees, then the valve is turned to the graduated point of one-tenth, and the steam will fill across the top of the radiator down one-tenth of its height. The water of condensation will flow down the sides of the radiator, and much of the heat contained therein be utilized for heating pur-

poses, and finally the water flows out of the radiator and to the basement through the return mains. If more radiation is wanted the valve is opened further. These different graduations are shown on the graduated valve which is now on the market. When the valve is wide open the steam occupies 80 per cent. of the space contained in the radiator. The question of graduating these valves has been a hard one, and it is necessary to go into the question of the amount of steam condensed per square foot per hour under certain conditions, assuming some average normal condition, and I believe that is the most satisfactory method of house heating I have ever seen, because it is absolutely under the control of the person occupying each room. The trouble with the ordinary steam radiator is, if you turn it on, it is usually too much for the most of the time when heat is needed during the year, and you overheat your rooms, and you use an unnecessary amount of steam. If you have a steam radiator that you can control simply by the valve, then it is very handy, and it seems to me to be a very great improvement in heating, and experience has shown that it reduces the cost of heating in a very marked degree.

Mr. Hale: Professor Kinealy has told us of tests that he has made which are in the same line of tests made by me, but I regret to state that I am unable to give the exact percentage of saving. However, I have been able to demonstrate an increased efficiency by the removal of air through a vacuum pump on the return line of a two-pipe heating apparatus. As to the percentage of saving, I do not think there are any data on the subject that have yet been given out.

Mr. Donnelly has mentioned the circulation of steam through pipe coils and pipe radiators, and that class of radiation as being more efficient than cast-iron radiators, and this is undoubtedly true on account of the space between pipes allowing for a more free circulation of air; the outer portion of a cast-iron radiator being all that could be called prime surface giving off maximum number of heat units, while its inner surfaces being close together will condense less steam per square foot. In my experience a single column cast-iron radiator or a wrought-iron radiator one pipe wide will give greater efficiency per square foot than radiators of greater depth. This also holds good in comparing a two-loop radiator with a three- or four-loop radiator.

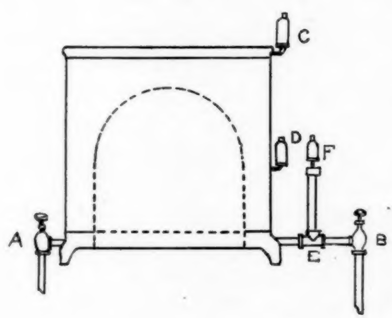
Reference has also been made to the use of hot-water radiators for steam use, and this recalls to mind a test that was made some years ago by a prominent radiator company at their warerooms in Chicago. This test was intended to show the comparative efficiency between steam and hot-water radiation where both were connected up for steam use, and it was demonstrated without a doubt that the hot-water radiator was not adapted for that purpose. The radiators were both connected with steam at the base and return at the opposite end, discharging into an open pail through a trap. The steam radiator filled and circulated perfectly throughout, the air and water being forced through the return connection; but in the case of the hot-water radiator, the top and bottom portions were filled with steam, air binding the centre. This air worked out in the course of time, but circulation was much slower, and the radiator less efficient than that constructed for steam use.

Reference has been made to the graduation of the amount of steam admitted to the radiator with vacuum air valves and ordinary supply valve on the feed connection, resulting in graduation of temperature, the admission of a small or greater amount of steam by the turning on and off of this valve.

I am interested in a system similar to the one just mentioned, where steam is circulated below atmospheric pressure, and by the admission of steam through a graduated valve a portion of the radiator can be filled, leaving the remainder of the radiator air bound. The admission of steam into the radiator up to its full capacity is under the control of the occupant of the room. Means are provided for preventing the air passing down into the supply line when the radiator is filled with air, the entire circulation of steam being at a point from two to three inches below atmospheric pressure.

Secretary Mackay: I do not understand from Mr. Bishop's description of his method of removing air whether the turn pipe had a pressure against it or, whether it discharged into the atmosphere. He has no air valve, and he has to discharge his air through the return pipe. It seems to me it would make a difference whether it was discharged through a return pipe or whether it was discharged into the air through a trap. In the one case it would form a back pressure on the radiator. The removal of air from a radiator, we all admit, makes a great deal of

difference as to its efficiency. I had a peculiar experience some years ago. I set up a hot-water heating apparatus for testing hot-water boilers. We used the ordinary hot-water radiation of that time; the radiators were base and top connection; it answered its purpose, gave us the information we were looking for, and was then left in place for heating the building. Later a steam boiler was constructed and we undertook to test it on this hot-water radiation—Mr. Donnelly probably remembers the case. The peculiar feature of it was that the boiler, which was ordinary in its construction, grate area, fire and flue surface, and should heat about 500 to 600 feet of steam radiation when it was new and the surface was clean, was actually heating one thousand feet of radiation. We had reports during the day every hour,



and the report of the night watchman every hour as to the pressure maintained, and the radiators were reported to be warm, but we did not consume the fuel that was necessary to maintain heat on one thousand feet of radiation, and, finally, after having several different men make the tests, I went over it myself and I found that the entire center of each radiator remained cold as per sketch, and the only way I could cure it was to put a "T" in the return connection, put in a piece of 1-inch pipe about a foot long, and then put in an automatic air valve, then I was able to extract 85 to 90 per cent. of the air that was in the radiator. Formerly the ends and top of the radiator were heated, but down in the center I found it was not heated, and about one-half of the radiator was standing perfectly cold except for what little condensation was trickling down. We were only getting an efficiency of about 50 per cent. of the radiation, and when we re-

moved the air the boiler, which was formerly carrying 1,000 feet of radiation, with from four to five pounds of pressure every night without any attention to the fire, would not carry more than half that amount.

Mr. Blackmore: It does not seem to me that the problem is entirely solved by the air removal, and I do not think the problem of air removal will be solved properly until experiments are made as to the consumption of fuel at the boiler, to determine not so much the efficiency or condensation of the radiator, but the actual amount of fuel consumed in a given operation; such an experiment might answer the question. Now, to explain further, if I may use the term, there is a certain amount of steam used in the mechanical effort of expelling air, provided there is no vacuum system attached to the radiator. Professor Kinealy, I understand, made this experiment with different degrees of vacuum, from 20 inches down, and he found that he got increased efficiency with the larger vacuum due to the greater condensation of steam. If the experiment had been carried further, with the vacuum system taken off, to see what efficiency could be had if the radiators were expelling air from the ordinary air valve, the experiment could have been checked up a little better, and it could have been checked up still further if he had gone back and found out the exact amount of steam used from the boiler to see what effort it had taken to expel the air from the radiator without the vacuum, that is, expel the air by the pressure of the steam. There is a measurable quantity of steam used for the purpose of expelling the air from the radiator apart from the condensation in the radiator itself. I have had occasion to make some experiments by putting a radiator in a tank of water, and I found, very much to my surprise, that the vacuum in this radiator that was produced did not increase the condensation in the radiator nor did it increase the temperature of the water. I found by increasing the pressure, however, in the radiator by throttling down the return pipe, I got a very material increase of power through heating the water in the tank and additional condensation; which indicates that when we put the vacuum on the steam does not impinge so hard against the radiator surface, and therefore there is not so much heat conducted through it. How far that applies to a radiator heating the air I have not been able to tell; but I do know this, that recently it has been shown

by a number of experiments that the same feed water heaters with different pressures, by blowing the pressure through the top and drawing the steam through an open return the efficiency for heating water fell down 25 per cent., but when they throttle the valve at the return pipe and allow the pressure to increase on the inside of the tubes they could get very much more hot water, so that the factor of the steam impinging against the inside surfaces to transmit the heat through by conduction from the inner surface to the outer is quite important. It may be possible to have a perfect vacuum in the radiator and yet not have the steam impinge on the inside of the surface sufficient to transmit all its heat through. I have not had an opportunity to test any of these things, as my time has been taken up by commercial transactions to the exclusion of such work. I would like to have some of the gentlemen who have an opportunity to make some laboratory experiments to try this subject out along the lines we have been talking about. I don't think it is entirely a problem of the extraction of the air that will produce the best results. Extracting the air from the radiator is one thing, the distribution of the steam in the radiator so that it will properly give off its heat through the surface, and through the surface to the air, is another. Then the amount of steam used to dispel the air in a radiator, presuming it is not on a vacuum system, is another thing that ought to be determined.

Mr. Mallory: In the tests conducted by the American Radiator Company on the hot-water type of radiator used for steam was the steam supply put in at the top or bottom?

Mr. Hale: It was put in at the bottom of the radiator.

Mr. Mallory: Were no tests made with the supply coming in at the top?

Mr. Hale: No. The tests were made for the purpose of demonstrating whether hot water or steam radiators were the most efficient as connected up by the ordinary one-pipe apparatus.

Mr. Mallory: Did Professor Kinealy make his experiments with the supply of the radiator at the top, and the return or the air vent taken away from the bottom, or was his steam supply taken from the bottom?

Professor Kinealy: I made no experiment with a cast-iron radiator with the steam connection at the top.

Mr. Bishop: I have made a good many operative as well as

laboratory tests on the question just asked, and have successfully used hot-water radiation for steam, but with no apparent gain in efficiency when the supply of steam was taken in at the bottom of the radiator. We have made tests for over three years on hot-water radiation with valve placed at the top of the radiator, two-pipe system, to determine the quantity of steam condensed. That is, to determine the quantity of steam condensed at a uniform pressure for division of tenths of the height of the radiator. We found that each tenth of the first nine-tenths of the radiator, from the top down, condensed practically the same amount of steam. The last tenth, the bottom tenth, fell somewhat short. There was simply a free opening into the return pipe on the return side of the radiator.

Mr. Donnelly: Where was the steam discharged?

Mr. Bishop: The discharge from the radiator was into the atmosphere during the laboratory tests.

Mr. Donnelly: How did you determine accurately when a tenth was heated?

Mr. Bishop: It took over a year to get the graduation right. With the air circulation at the bottom we could detect the difference exactly.

Mr. Donnelly: How? With your hand?

Mr. Bishop: No.

Mr. Donnelly: With a thermometer?

Mr. Bishop: Yes, in some instances. Tested against the radiator itself at the different points, but in most all tests by the weight of water discharged. You could hardly determine it with your hand.

Mr. Donnelly: I can see how it would do with the upper part, but when you got down to the lowest part, the last nine-tenths, that would be heated to some extent by the hot water, would it not?

Mr. Bishop: Yes.

Mr. Donnelly: Therefore, when you got down to the last tenth, that was already 60 per cent or 70 per cent. heated with the water, was it not?

Mr. Bishop: The water was measured. You could not get at it any other way.

Mr. Donnelly: But the water did come out. When it heated the upper tenths it would come down, it would come out way down in temperature to 120 or 150, would it not?

Mr. Bishop: Down nearly to the temperature of the air.

Mr. Donnelly: When you heated the entire nine-tenths of the radiator the water would not give out as much heat?

Mr. Bishop: Not quite ten times as much as the first tenth.

Mr. Donnelly: Therefore, the last tenth you would be heating with the water, therefore you could use the condensation of the steam that came trickling down into it for that purpose.

TOPIC NO. 2.

"The Proper Air Space Between the Surfaces Exposed in the Heaters of Blower Systems."

DISCUSSION.

Mr. Kinealy: If the pipes on a hot blast coil are about $2\frac{1}{8}$ inches centre to centre and the air passes through the coil with a velocity of 1,000 feet per minute, we get a certain heat effect. If the pipes are 3 inches centre to centre, to get the same heating effect we have got to have coils that will be twice the number of pipes in depth that we would have if they are $2\frac{1}{8}$ inches from centre to centre. In other words, if the pipes are $2\frac{1}{8}$ inches from centre to centre, the coil would be, say, 16 pipes deep; if the pipes are three inches from centre to centre, the coil would be about 34 pipes deep. If the coil is 16 pipes deep we can arrange that coil to have four connections, each connection taking a valve and a pipe. If, on the contrary, the coil is 34 pipes deep, then if we have four pipes in depth of the coil to a connection we shall have 8 connections, 8 pipes and 8 valves. If we put a header and divide the coil up into four parts, as we had when we had the coil 16 pipes deep, then we shall have 8 pipes to each of three of the headers, and 10 to one of the headers. That means larger valves. All of this means that if we get the pipes close together in the coil, the coil will take less space, and the cost of connecting the coil will be less than if the pipes are far apart. It is impossible to make a coil having a return bend and 4 pipes to a base without putting the pipes $2\frac{3}{4}$ inches from centre to centre. Otherwise their connection at the top cannot pass between adjacent pipes. The result is that if we use a four-pipe base we have got to have the pipes pretty nearly 3 inches from centre to centre, or we have got to use such a base as the Sturdevant. I like a

base that has the pipes $2\frac{1}{2}$ inches from centre to centre and 2 pipes to a base, because I can buy that of any manufacturer; it is a base that is easy to circulate and that heats fairly well; it takes more space than a base having pipes $2\frac{1}{8}$ inches from centre to centre, but not as much space as a base having pipes 3 inches from centre to centre. I think that within reasonable limits the closer we get the pipes together the more effective is the heater, and the construction of the bases is usually such that we cannot put them much closer than $2\frac{1}{8}$ inches from centre to centre.

Mr. Blackmore: One point that was not brought out: I presume the tubes were staggered?

The Secretary: In every case.

TOPIC NO. 3.

"In blower systems of heating and ventilation, what are the maximum allowable velocities in the different parts of the system, and what limits the velocity and why is it limited?"

DISCUSSION.

Mr. McCann: In a great many cases in school work I find that when the velocity is too low the result is as bad or even worse than if the velocity is too high. The limit, therefore, is what you might call a happy medium. If you get a velocity too low the air will return from one flue to the other. We have had some cases in schools where the air would go from one class room down into the main trunk, and then up the other flue because the velocity in the main trunk was so low there was not pressure enough apparently to force the air into the class rooms, and the outside influences overcame the force of the blower. On the other hand, if you get the pressure or the velocity too high, the rattling of the dampers or ducts will cause noise that will be objectionable. We find in school practice as a rule that a velocity of fifteen to eighteen hundred feet a minute in the main ducts at the blower was not objectionable, being even advantageous, and the velocity should be decreased of course until in the class room this velocity would be about 400 or 375 feet a minute, the ducts leading to the class rooms having that flow per minute. Of course, what I have said applies to the larger blowers; where we have smaller blowers we never have the

velocities so high in the main ducts, as there is no necessity for so much pressure.

Mr. Kinealy: I would like to ask Mr. McCann a question. What pressure do you run your blowers at when you have a velocity of fifteen to eighteen hundred feet?

Mr. McCann: I don't know; I have never measured the pressure, but from various blower catalogues we figure three-quarters of an ounce; I don't suppose we get exactly that, but I have never measured the pressure to see.

Mr. Kinealy: Well, you run the blower at the speed to give three-quarters of an ounce?

Mr. McCann: Supposedly, yes.

Mr. Lewis: I would like to ask Professor Kinealy what he considers a good approximate speed of the air through the heater.

Mr. Kinealy: I don't know what is the best velocity to give the best results in efficiency, but for ordinary school and hospital work a velocity in the neighborhood of 1,000 to 1,100 feet per minute gives good results. For factory work, a velocity in the neighborhood of 1,200 to 1,400 feet is good, although, of course, that means running the blower at a speed to give a high pressure. The friction of the air through the heater is considerable, and increases very rapidly as you increase the velocity. Ordinarily, if you are running the blower at a speed to give a pressure of half an ounce the friction of the air through the heater and the fan will be such that you will have not more than three-tenths of an ounce to overcome the friction in the pipes when the air passes through the heater at a velocity in the neighborhood of 1,000 or 1,100 feet; and if you increase that velocity then you decrease the available pressure to force the air through the ducts or pipes into the rooms, and you also decrease the pressure you can maintain in the room and thus keep out the air from high winds.

TOPIC NO. 4.

"Summer Tests of Heating Systems."

DISCUSSION.

Mr. Chew: Maybe I can say a word here. My idea in putting that on the programme was because some time last fall one of our correspondents wrote to us for some help in satisfying a

customer as to the efficiency of heating systems which could be fully tested for the winter weather during the summer time. Then about a month or six weeks ago Mr. R. S. Thompson, who is here, sent me a circular showing the temperatures that were secured by two different furnace-heating systems using natural gas for fuel with the temperature out-doors I think about 70. In response to what we printed to satisfy our correspondent we asked the information of another man, and I think he said that when the temperature out-doors was about 70, with an indirect heating system, if you got a temperature about 104 in the building you could calculate that that same building could be made comfortable when the outside temperature was zero. Mr. Thompson is here, and if you want he probably can and will add something.

Mr. Thompson: Well, the amount that I do not know about making summer tests of heating apparatuses is so great I would not undertake for a moment to put in a job and guarantee the heating of it by a summer test. I tried to get some information on that point which was reliable. The tests that I made were comparative tests; it was not to determine whether the thing could be done, but simply to determine the relative consumption of fuel in two different heating apparatuses. That is all that test that I had to do with in the summer time amounted to. Incidentally I took some memoranda while making that test, and the memoranda I got did not encourage me to believe there was any great difference in heating 70 degrees above outside temperature whether the outside temperature was 70 or zero, but I did not get data sufficient to make a definite argument upon that. I found out in the first place that it took a great deal more gas to heat the rooms from seventy something up to 110 than I had calculated on the same ratio of heating the buildings from zero to 70. But there was a bad error in the calculations. In calculating on heating the rooms from zero to 70 in cold weather I had assumed only the two outside walls, which of course is what we have to contend with, with a corner room, a room like this, or a school building, with two walls exposed to the air, and the other walls connected with other rooms. In testing these rooms—we had only those two rooms to heat—these two inside walls were practically outside walls, because the temperature of the rest of the building was the same as the outside air,

and in making due allowance for it and making allowance for the time it took to get the bricks heated up, it appears to me that I got better results in proportion to the temperature with the thermometer outside at 72 than I would have dared to trust myself to get when the thermometer was zero. But it seems to me the whole thing is in a chaotic condition, and there ought to be something additional ascertained so as to enable a person taking a given temperature to answer this kind of a question. The table published in the *Metal Worker,* giving a basis of 104 degrees as the inside temperature, outside temperature at 70, as corresponding to the temperature of 70 inside and outside at zero, I don't believe, nor could I satisfy the average man on that unless it was backed up by some pretty good authority, so that when a man states that to a customer he should have some authority to make the average customer believe that it is true.

Mr. May: It seems to me this very discussion gives reasonable ground for taking sides with Mr. Jones in his paper. If our ratios were correct, it would seem a very easy matter to determine the temperature of the water or steam pressure which should be maintained to give a certain inside temperature when the outside temperature were known. It would appear that there is a variation in the transmission from radiation, which has not yet been determined, and which transmission is not at a uniform ratio, and until the variation in the ratio which exists can be determined, it would appear to be absolutely impossible to establish a rule good for any and all variations in temperature, or which could be used to establish a basis for summer testing. Several rules have been formulated which do not appear to work out satisfactorily. These rules appear to have been based on a uniform heat transmission, but when actually tested do not give the required results. For this reason I believe that some of the suggestions offered by Mr. Jones are worthy of careful investigation, and this Society should be in position to make such investigation in order to get at the facts.

Mr. Kinealy: This was all thrashed out years ago in this Society. We worked on it, and had committees that worked on it for two or three years, and the result of it was that we did not see our way to do anything with indirect radiation or fan systems, or with furnace systems; in other words we did not see our way to do anything where it was not only a question of loss

through walls and windows, but also a question of ventilation. If I remember right—yes, I am sure—the committee formulated and submitted a report that was adopted by the Society establishing a standard method of testing direct radiation jobs; but I think that the report required that the tests should be made when the outside temperature was below 45. Do you recall, Mr. Blackmore, you were on that committee?

Mr. Blackmore: I think it was forty-five. I recollect it was very indefinite after we got above that figure.

The President: That was by actual experiment, was it, Professor?

Mr. Kinealy: By all the experiments, Mr. President, that we could get; we searched the literature of all the civilized countries and made tests and got experiments and every information we could, and I think that afterwards the Committee on Tests was instructed to make some tests; I don't remember whether they did or not, but the Society worked on that question for fully three years.

Mr. Blackmore: I know the committee made an urgent request to the members that they should make tests and present the results to the Committee on Standards. No one seems so far to have undertaken it. I think it is possible to test a house in other than zero weather; I do believe it can be tested up to 45 degrees, and it is not necessary to wait until mid-winter to get a job off one's hands.

Mr. James Mackay: How would Mr. Blackmore figure that out if a heating apparatus was put in to-day? Would he wait until it was 45 degrees to make the test?

Mr. Blackmore: Well, that would lessen the hardships if that was the test; it would be a great deal better than to wait until it was zero. We always get a temperature of 45 very early in the season. Previously some poor contractor would often have to wait until midwinter, or even until the next winter, because he did not get zero weather during one winter. There ought to be some effort made here to have some reasonable test that could be made in comparatively cold weather, because we have 45 degrees always early in October or November. It was felt that such a rule would be reasonable, and it was set down at 45, believing such would lessen the hardships the contractors have to suffer. Inasmuch as we could not make a rule for higher tem-

peratures it was considered safe to apply it up to 45 degrees, which would be much better than leaving it at zero.

Mr. James Mackay: There are a great many parts of the country that do not reach that temperature. We might have it here early in October, but there are many parts of the country where they do not have it until very late in the winter.

Mr. Blackmore: This committee at the time did not have any complaint from those sections of the country that don't go down below 45 degrees.

Mr. James Mackay: I don't think those things should be based upon someone's complaint. They should be based upon utility, whatever is best for the general good.

Secretary Mackay: This plan of testing plants during the summer months at certain temperatures instead of waiting for zero weather was brought up by a complaint; somebody had a contract to build a heating plant and test it at zero weather, and the records of the place and the records of the Government showed that that particular place had never had zero weather; it was brought about in that way, and I am of the opinion now that the report was printed but not published in the *Transactions,* it is the records in pamphlet form, and if anyone wishes to have it looked up we can furnish copies of it.

Mr. Blackmore: As I recollect, the report was received and put on file with the idea that we would get verifications by actual tests from the members, and if we could once get those it would go a long way towards establishing this rule as being satisfactory. It is impossible to make a rule of the kind absolutely scientific, and while I believe that Professor Kinealy did practically all of the work, I went over it with him, and I have reason to believe that a test made on the basis of Professor Kinealy's report would be satisfactory; but until it is verified it would be hard for us to lay it down as a standard rule. In making a test of that kind in comparatively warm weather one test is not sufficient, at least a dozen tests should be made so as to strike an average and show how much error there would be in the calculation.

Mr. Chew: It might be of interest to this committee to know that Edward S. Berry of Philadelphia, one of our members, is interested in this question. Whether he has any information on the subject I don't know, but if Mr. Blackmore or Mr. Kinealy

would make inquiry of Mr. Berry he can say whether he has any further information or not. I am inclined to think that the discharging of a committee and accepting the report is a bad thing. I think that the committees should continue a long time; this gives an opportunity to concentrate their powers on some particular subject, and if they go along from one year to another knowing what their particular job is, whether it is looking after summer tests or looking after data on heating of one kind or another, I think that these committees will do better work; I think the Society is more likely to have gathered at some time or other a lot of information for the committee on standards and tests. Whether it would be absolutely accurate or not makes no difference; it simply gives the parent committee a final opportunity of asking for more information on different lines. Another thing I want to bring out, Mr. Lewis said that he would be willing to be one of a committee to figure out some of the things in Mr. Jones' paper and report at a later session. I believe the Society would get a great deal from this suggestion if it was carried out. The Society is to be congratulated on the way things have been going during the last three or four years; it is certainly making progress in the right direction.

Mr. Blackmore: Mr. Chew starts a thought that I think ought to be acted on, and if you will pardon me for making the suggestion at the present time, I think the President in appointing the committees on standards and tests should make it obligatory on those committees to go over the work done by previous committees, and the work that is incomplete they should continue till a complete report is made. Now Professor Kinealy and myself were superseded by the appointment of the new committee on standards, and I have every reason to believe the matter was dropped entirely. It is hardly within the province of a prior member of the committee to make suggestions to the new committee, but it would be quite proper for the President to draw the attention of the new committee to such uncompleted reports when he is making the appointment at the annual meeting. I think this paper ought to be analyzed thoroughly between now and the annual meeting. It would be a good thing to do that with all papers, and even if this paper had no other value, it has shown us what the English practice is, and how at least one of our members there has done this work. I think that paper ought to be brought up again at the annual meeting.

TOPIC NO. 5.

"Natural versus mechanical and upward versus downward ventilation for rooms in school and larger auditoriums."

DISCUSSION.

Mr. McCann: Gentlemen, I would like to have this topic given as thorough a discussion as possible, because of the fact that in all public schools, public buildings, etc., we have to use mechanical ventilation, and I think that the use of mechanical ventilation is believed in by all competent engineers; but doctors, teachers and parents of children who go to these schools, and people who go to public halls, and so forth, do not appreciate the necessity for mechanical ventilation or the feasibility of the same. I know in New York at the present time there is considerable discussion on the matter, and the daily papers have criticised the ventilation of the New York schools a great deal, based on the idea that an open window is the only means of getting any air of any value into a room.

TOPIC NO. 8.

"The effect of the size of the mains on the height of the water line in different parts of a gravity steam heating system."

DISCUSSION.

Mr. F. F. MacNichol: I am not a member of the Association, but I would like a little information on this question. I am a heating man in a small way, and I installed a steam heating plant in Oshkosh two years ago, with two boilers in it, heating a school house, a large church, and convent from a central plant. The plant in the church originally was hot water. That proved a failure on account of lack of surface, and when they built a new school house we used the same piping that was made of coils and headers on the space against the walls in the church. I turned that into a double pipe steam job; I left the mains in the church underneath the same as they were, five inch flow and returns. Those pipes in the church figured up about 3,000 feet of radiation; I carried a 6-inch main over

to the church, and I have only 8 inches between the lowest point in the steam main and the water line; I heat the church and school house and the Sisters' house, with not to exceed three pounds of steam, most of the time two and a half, and the water makes no attempt to leave the boiler. If you will tell me why that is, I would like to know. The pipe is a 6-inch pipe coming off the top of the boiler; it runs to the wall of the building, dropping down and going through the walls underground over to the church, and there is an 8-inch water line there. I was scared to death when I did it, I never did a job like that before in my life, but they would not have the pipe run across lots between the buildings and the church. I am at sea to know why the job works. I assure you it does, because I got my money for it.

Secretary Mackay. I suppose it is a gravity apparatus that he is describing, he does not say so, but I suppose it is. Of course it is altogether a question of the size of his flow main and return—the pressure throughout the entire system makes the system a part of the boiler.

Mr. Donnelly: I would like to ask the gentleman from Oshkosh where the return pipe is, whether it is above the water line or not?

Mr. MacNichol: It is on the same level with the flow pipe.

Mr. Donnelly: Then it is above the water-line of the boiler?

Mr. MacNichol: It is above the water-line of the boiler, yes, sir, until it comes near the boiler.

Mr. Donnelly: I ran across a case exactly similar to this down in Pennsylvania ten or twelve years ago. I was travelling through that section of the country and a steamfitter took me to a school and convent very much similar; there were two or three buildings and a horizontal tubular boiler gravity plant, gravity return, and he had steam and return mains on the same level as the drip pipe that carried from the steam main across about two feet, and from the side of the return main the drip pipe was cramped; I guess there was an 8-inch drop in the steam main, possibly half the diameter of the return below the steam main. It was impossible through this passageway between the two buildings to put the mains in overhead. He showed me those under the floor, and how he was going to box them in, and afterwards asked me if I thought it would

work. I told him I didn't think so, I didn't see how it could. I looked it over there and told him it didn't seem possible that it would work. Now in this case I presume there is a drip from the steam to the return main at that point where it drops down?

Mr. MacNichol: The only drip I have is from the flow pipe into the return to take care of condensation that would otherwise come back to that pipe.

Mr. Donnelly: That goes into this return line above the water and it flows out above the water-line.

Mr. MacNichol: Right close by.

Mr. Donnelly: Well, I went back through that section some seven months afterwards when the apparatus was working and I asked the man, I was interested to know if it had been successful, and he said it had been. I looked it over, I thought over it for a long while afterwards and finally made up my mind there was quite a demand for steam in the return line at that point; if you will consider that main return as a steam radiator, it makes no difference, you will see there must be steam feeding into it by the pressure; you must fill it with steam; the air that is in it probably don't all get out, a considerable portion of it would be compressed; there is a flow of steam through the system to the return main at that point, the pressure in the return main being similar to the steam main, due to the friction of the steam from that point back to the same point; therefore being a lower pressure in the return main there is a flow of steam from the steam main to the return main which not only carries that water of condensation into the return main but carries the water with it, and the water is a minor factor. Now that is comparatively smaller in volume, although it may be considerable in weight; therefore it is on that principle, I am satisfied in my mind, that that is the reason why this job worked. I think that is practically the same in your case.

Mr. MacNichol: The only pipe into which the return drains is about 18 inches below the water-line. If any steam gets in it would have to work up through the water.

The President: Is there any further discussion on Topic No. 6? It is a very interesting topic.

Mr. Chew: I think I am correct in stating that both Mr. Mor-

gan and Mr. Mackay agree that the reason he had no trouble is due to the large sized mains as compared to the amount of radiation carried. If I have not stated that correctly, I will be glad to be corrected.

Mr. Morgan: Mains and return. I will say that I have been called on once or twice to stop a boiler throwing its water, and the only remedy I offered to put in was to increase the size of return pipe from where it had been reduced to full size so that the boiler—you could not raise the water at all in the boiler—could not get a particle of fluctuation after that kind of treatment. I presume it is due entirely to the differential in pressure, doing away with the friction in the smaller pipes.

The President: Will the gentleman tell us what proportion he increased the sizes?

Mr. Morgan: I carried it full size; in one instance that I recall where I had a 2½-inch pipe reduced to 1½ inch, I carried it 2½ inches; I didn't see that it fluctuated the water-line in the boiler.

The President: And the return pipe, the same size as the steam main?

Mr. Morgan: Yes; not only would it fluctuate in the boiler, but it would come up into the radiators and pipes. I think possibly if I had carried full size to a point near the drip and left it a smaller diameter beyond the drip it would have exactly the same effect.

Secretary Mackay: My experience has been similar to Mr. Morgan's. I had a somewhat similar case to that stated by Mr. MacNichol, where there was a church, a convent, a parochial school, and a parochial residence, a boiler was placed under the church and mains were dropped down just as he says, to go in under the ground, and at that point so as to get them low enough to protect them, it was very close to the water-line of the boiler. I found in that case, as in other cases where the return is too small, that when they were enlarged, without changing any other part of the apparatus, the boiler, steam mains, or radiators, it worked satisfactorily where formerly it had been nothing but a failure.

The President: You overcame the friction, is that the idea?

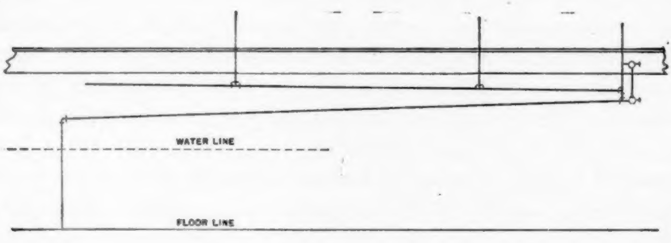
Secretary Mackay: Yes, overcame the friction and increased the body of water. I described an apparatus at the last annual

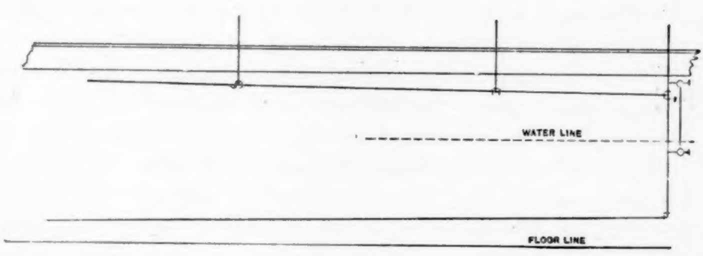
meeting, where there were two steam mains 100 feet long and 4-inch diameter, and 2-inch returns coming from the extreme end; that return was enlarged to 3 inches. Now while a smaller return might have done, I am happy to say that that apparatus is working to-day. In that case, the steamfitter said if I remained in town until he did the work he would change it, otherwise he would not. I remained in town until he changed it and it worked all right, and so far as I know to-day the same apparatus is working and giving satisfaction.

Mr. Donnelly: I was interested in what Mr. Morgan stated. Different men have different ways of overcoming difficulties. I saw a boiler a short time since which when it was fired up with the water-line within an inch or two from the top of the glass, the water would go down 7 or 8 inches when steam was raised, and was asked what to do in connection with it. I advised putting in a steam separator. After that we could fire the boiler and get all the steam we wanted, and we found that the water would drop less than an inch. The water instead of going through the steam main would drop from the drip of the separator and go back into the boiler. We could force the boiler very hard and get very good results. I think it is a well-known fact in the trade that in the production of steam the lower the pressure the more difficult it is to produce dry steam; with high pressure it is easy to produce dry steam, and I think in producing steam close to atmospheric pressure the boiler would be very much more effective if it had a steam separator on the steam mains. I believe the boiler manufacturer who has the courage to put out a boiler equipped with a steam separator would get large returns. It would make in every way a better working job. Now in connection with Mr. Mackay's remarks about pipe sizes, in noting the sizes that we received in answer to these questions, it has been very interesting to see that there are some men that have made experiments with pipe sizes. They have taken, for instance, the smaller pipe sizes and tried to reduce them to see if they could be made smaller, and the answers certainly have shown that they could. Now in making these experiments it is probable that in order to be safe-guarded in their sizes, they have reduced the size in some pipes, and possibly have increased the size of others. You may pipe out a job and put the larger sizes a

little larger than necessary, larger than the uniform rule would make them, and then cut down the smaller sizes, and you simply make the result the same. You get a higher friction in a smaller size, and not quite so much friction in the large sizes. On the contrary other answers have shown some opposite experiments that have been made. Some men have reduced the larger sizes and increased the smaller sizes, and I think that the greatest benefit in the collection of these data will be its tendency to assist in the adoption of a more uniform scale of sizes. In these answers I have also noted that the high answers were not received all from the same person; a man will be high in some sizes, and his line will drop down, and another man will be low, so that the high and low answers received are probably each of them the result of three or four men's answers. There seems to be a lack of uniformity; and I think it is on account of some man giving small answers on only one particular size. If we follow the result of the tabulation shown in the diagram, we find that the lines come closer together in the middle, so that the answers are very much more uniform in a reasonable size, say 3-inch or 4-inch or 5-inch size, they have not loaded those sizes up the way they have in their experiments with small sizes and the larger ones. The same practice comes in the steam mains; if the steam main is made small and the return main made small you have trouble that can be corrected by either making the steam or the return main larger. It is a question of the sum of the two frictions, and by saving in one size and increasing it in the other, the same result is obtained, but not in the same uniform manner. Take this average, it is true that any man can prove that average wrong, and that any one size pipe is capable of carrying a great deal more radiation than that given. For instance here is a table, and a man might say in regard to that table, "I will put this amount of radiation on all sizes except 2-inch or 3-inch, and that I will put more radiation on." He will probably get good results, because the slightly increased amount of drop will not interfere with the apparatus working; but if he were to attempt to apply that rule generally, to apply it to all other sizes, he would get into trouble; and I think the greatest benefit of that will be that eventually there will be a uniform scale of sizes, so that we will have a uniform drop in all sizes and a more uniform practice.

Secretary Mackay: The topic is "The Effect of the Size of the Mains on the Height of the Water Line in Different Parts of a Gravity Steam Heating System," and the party asking that mentioned a case where 100 feet away from the boiler the water stood 24 inches higher in his system than it did in his boiler, which would indicate, it seems to me, too small a steam main, or too small a return, or both. Now, can we blame this on the boiler? I have frequently found that boilers were blamed for doing things that were done by the steamfitter on the job.





I have investigated a number of gravity steam apparatuses where it was claimed the boiler lifted water into the radiators and I found on investigating and placing water gauges on the mains in the basement that on account of the size of the steam and return mains and the friction the pressure was reduced at the extreme ends where it was most necessary, and as a result the water raised at these ends until a steam main which was ordinarily from 20 to 30 inches above the water-line of the boiler was partially or wholly submerged when the boiler carried a pressure of 5 pounds. This has been remedied by the placing of larger steam and larger return mains allowing a uniform pressure in all parts of the system and a uniform

water-line. I show two cuts illustrating the application of these water gauges in both wet and dry returns.

Now as to the necessity of selling a separator with a boiler, I don't think that is an absolute necessity. Some water tube boiler manufacturers recommend separators being put on. I have known of cases in gravity apparatus so arranged that the moment you got steam on the boiler the steam main was filled with water 50 or 75 feet from the boiler. Your pressure of steam is going to force the water in the steam main ahead of it into the radiators. The boiler is often blamed for the water in the pipe, when really it has nothing to do with it; the boiler generates steam, or forces the water in the steam main towards any opening or air valve that may be in the radiator or at some other point in the apparatus. I find by enlarging the steam and return mains that you get relief. I have in mind a case similar to one case that has been spoken of here, I remember where there were four buildings, in three of them the steam main was below the water-line of the boiler in a gravity apparatus; the boiler had but one function to perform, the generation of steam. All it could do was to lift the weight of the water in the steam main ahead of it into the radiators.

Mr. Donnelly: It is a very good practice to make outlets from the boiler as large as possible, considerably larger in area than the steam main. Probably the fact that the ordinary house heating boiler delivers more entrained water than steam is due a great many times to the comparatively small surface that is provided for the release of steam on the surface of the water. It is a very hard question to talk about or have anyone arrive at any safe conclusion that would be conceded to be satisfactory. The Committee on House Heating and Steam Boilers might collect some data on that as to the different performances of boilers with different amounts of exposed water lines, surface and sizes of steam drums. Of course, in a horizontal tubular boiler there is a much larger surface for releasing steam, and when we consider we are making steam at atmospheric pressure in very large bulk in the ordinary pipe cast iron sectional boiler with very limited water-line surface, it is surprising that we do not get more entrained water into the steam main than we do. Low velocity is probably a most important factor in allowing entrained water to drop. Aside

from that it is well to use some simple form of double impact surface, and I spoke of this form of separator. It would cost less than three 5-inch connections to one 5-inch main, and it would be fully as efficient, probably more so.

Mr. Morgan: I wish to take issue with Mr. Donnelly; it is not a question of freeing steam from water, it is a question of reducing the pressure. The initial pressure is in the boiler. If you provide main and return of proper proportion the steam will come out and the friction will not be sufficient to amount to anything, so that the water will rise through the return. There is where the difficulty is, that is where the boiler loses its water, it loses it through the return pipe; and from the time of starting it from the boiler, $2\frac{1}{2}$ pounds becomes less than $2\frac{1}{2}$ pounds before it goes around to the return; the pressure in the boiler is $2\frac{1}{2}$ pounds, it simply raises the water through the return out into the return main, and that blocks your system, that is the impression I wanted to leave with you.

Secretary Mackay: The question is, "The Effect of the Size of the Steam and Return Mains on the Height of the Water Line in Different Parts of a Gravity Steam Heating System." In this particular case the effect is 100 feet away from the boiler, the water-line stood 24 inches higher than it did in the boiler. It is not a question of wet steam or dry steam or separators or anything else; the question that this gentleman wants to know is, why his system worked with the mains only 8 inches difference between the lowest point of the return. He asks why does it work; the other man asks why it does not work? He wants to know why it does not keep the water-line uniform throughout the system. I believe the reason is that the steam main or water return main is too small. Now this gentleman has ample mains for the amount of work he is doing, and for that reason the water-line remains almost uniform in the system with what it is in the boiler.

TOPIC NO. 9.

"The relative economy in fuel of steam, vapor, vacuum, and hot water heating for residences."

DISCUSSION.

Mr. Bishop: I might make a suggestion upon this question to start the argument along. I want to put a question to the

members here: Will anybody disagree with me in this statement, that it requires the same number of B.T.U. per hour to heat a room or a house, regardless of whether those thermal units are supplied by the sun, through a magnifying glass, or from a hot air furnace, a stove, oil lamps, steam, hot water, vapor, or anything else. In other words, does it not require just so many B.T.U.'s to heat a room to a given temperature, and does not the whole thing come back to the efficiency of the generating apparatus, or, in other words, to the design of generating apparatus which produces or transfers the greatest amount of heat from the coal and conveys it into the room to be heated?

Mr. Kinealy: I think Mr. Bishop's statement is true, and it

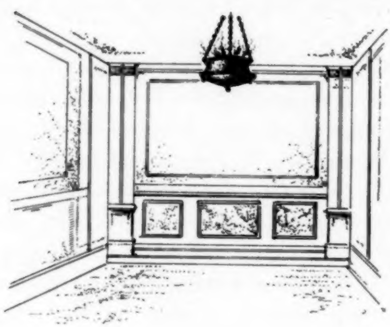


FIG. 1.

is not true; it depends entirely upon how you interpret it. It is true I think that you can put one apparatus in a room and that apparatus will require more heat units to generate and maintain a given temperature in the room than another apparatus. It depends upon the efficiency of the utilization. If you mean that under a given set of conditions does the same amount of heat units pass through the walls and windows and other cooling surfaces, then I say Yes. If you mean if we put into a room a certain number of heat units under one condition will it maintain the same temperature in the room that the same heat in another condition will, I don't think that the statement is true. I can illustrate that in this way: Let me assume this is a room, the floor being marked "A," the floor being thick and made of non-conductive substance, the sides and

ceiling are made of sheet iron (Fig. 1). I will now put into the room a charcoal brazier, that is a little bucket having a charcoal fire, and I will put it against the ceiling; the bottom of the brazier is covered with non-conducting material. By burning a certain number of pounds of charcoal I heat the ceiling, but I do not heat the room; the heat goes through the ceiling to the outside. If I lower the apparatus so that I do not concentrate the heat from the charcoal on a small portion of the ceiling less charcoal will be burned in the brazier to heat the room (Fig. 2). Isn't that true, Mr. Bishop?

Mr. Bishop: Certainly.

Mr. Kinealy: I have answered your question, I think.

Mr. Bishop: I might have added further to the question, by

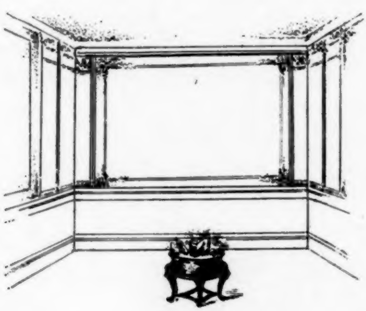


FIG. 2.

assuming that the point of inflow of the heat currents remained the same, or that the location of the heating apparatus in the room was unchanged, whatever the kind of apparatus; whether a hot air apparatus, direct or indirect steam or hot water radiators, or a furnace, or the sun's rays, all coming from the same point.

Mr. Kinealy: All right, take that, then. I put in here a radiator close to one of the walls and I heat that radiator to a temperature of say 300 degrees or a temperature given by steam at about 100 pounds pressure (Fig. 3). The wall close to the radiator is heated to a very high temperature and there is a very large conduction of heat through that wall, and the apparatus will require more heat than if we put in a larger radiator in the same place and maintain in that radiator a tempera-

ture of 100 degrees, because there will not be so much heat lost through the adjacent walls (Fig. 4).

Mr. Donnelly: You are heating more walls with the smaller radiator?

Mr. Kinealy: Yes, heating more wall with the smaller radiator.

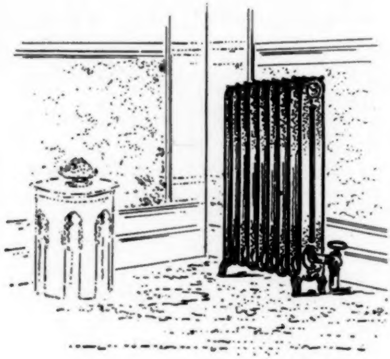


FIG. 3.

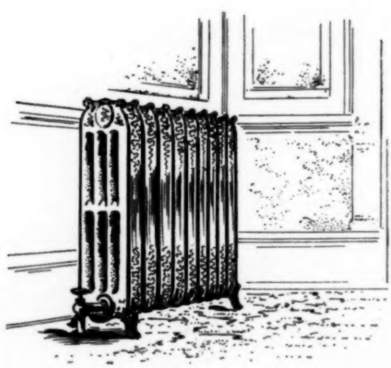


FIG. 4.

Mr. Donnelly: A small wall with lower temperature may be the same as more wall with a higher temperature.

Mr. Kinealy: That is true. I made such experiments and the explanation I have given was the only way I could account for the fact that a highly heated body close to an outside conducting surface means a larger expenditure of heat to maintain a room at a given temperature than a colder body.

Mr. Hoffman: Professor, I would like to ask, is it not some-

what dependent too upon the amount of surface that you have? You are depending upon the circulation there to heat the room, the greater surface you have in length and height and breadth, the more air you will circulate over that heated temperature, consequently you are heating a room a good deal quicker than you do if you had a very small amount of surface concentrated at a higher degree of heat.

Mr. Bishop: You get the same number of B.T.U.'s in the room.

Mr. Davis: Why not put the radiator in the middle of the room?

Mr. Kinealy: The higher the temperature, the more heat will be required.

Mr. Morgan: Maybe I am asking the same question that Mr. Bishop put, but it is one that occurs to me, and that is which apparatus will produce in a room the most units of heat in a room per ton of coal consumed. Did Mr. Bishop ask that question?

Mr. Bishop: Well, that question is practically the one I asked. I still contend that the construction and design of the heating apparatus itself is the question. To illustrate that point, my house was originally heated by a furnace, and afterwards I put in a hot water system, and an average of three years was taken to determine the quantity of fuel used, and later on I put in a steam heating boiler, and used the hot water radiation, did not change its location at all; I left the radiators where they were, and on a three year average with that apparatus it showed considerably more than $80 difference in favor of the steam apparatus. Now I don't want to be misunderstood in saying that the heating of the house was cheaper because it was steam. It was simply cheaper because the generating apparatus itself was more efficient as a medium of extracting heat from the fuel and placed it in such form as to transport it into the house with the greatest efficiency.

Mr. Morgan: Mr. Bishop is all right, and it simply comes down to the proposition of combustion, at a somewhat higher temperature; after heating his radiators his boilers were closed up, closed off, for a longer time than if he was using water; it is entirely a matter of friction of the water in the pipes, in my opinion.

Mr. Donnelly: No doubt the most satisfactory apparatus is one that can be placed in a room, so that the heat can be turned up and down in the same manner as a kerosene lamp or gas jet. We have been trying for a great many years to get that sort of an apparatus, and we are still trying. The most economical apparatus of the future will be an apparatus that gives each person just the amount of heat he wants in a room; so that a man sitting alongside of a radiator will have no limitations. In such a case it will not be necessary to have directions as to whether he shall open the valve full or little, whether he must close it very tightly when he wishes to shut it off or whether when he opens a valve he must be sure to see if the air valves are in proper repair. We should have such an apparatus that if a man wants to produce 60 degrees in a certain room, and some one else in another room wants to get 80 degrees, they ought both to be able to be satisfied. If we can get a heating system that will diffuse heat in that way, it will be one that will give heat with the most economy, and it would soon be universally used. I think it is safe to say that there has been no considerable improvement in steam systems in house-heating for the last thirty years, and I suppose it is up to a growing Society, such as this is, to produce some startling changes in a heating apparatus for residences with mechanical improvements such as would be worthy of most of the other lines, such as plumbing, lighting, and all the other conveniences in a residence. The greatest improvement would probably be something that would give us a form of damper control, or a form of hand control, so that each person in a room could fit the heat to suit himself without having to study a book of directions and being sure that the steam valve was packed right, and everything like that.

Secretary Mackay: The gentleman who asked this question is a member of the Society and is in the habit of doing a good class of steam and hot water work in all classes of buildings. I understand it is principally gravity, although he does other work, and according to his question, it seems to be a question in his mind whether there was sufficient advantage and economy in vapor or vacuum systems to counteract any additional cost or warrant their installment in place of the gravity system, low pressure, or a hot water apparatus, heating a building to 70 degrees, six or seven months during the winter.

Mr. Brennan: I have found cases where there was a low pressure system of heating apparatus in the building where there was more radiation than the boiler would carry and the engineers would say, "We will put on a pressure and reducing valve, we will run the pressure up to 60 or 70 pounds and reduce it, and run it through the radiators at low pressure, which is more efficient, and gets better economy." I have talked with a great many engineers where they used the vacuum system with low pressure and used an electric ejector pump to pump the condensation back, and by increasing the pressure to 60 or 70 pounds they show a saving by that. I would like to have some of the members express their opinion regarding forcing the boiler by increasing the pressure to 60 or 70 pounds and then reducing it two or three pounds in their radiators, pumping it back into the boiler.

Mr. Schaffer: I would like to ask Mr. Bishop whether he reduced the amount of radiation? Hot water requires more radiation than steam, and I would like to ask him whether he reduced his radiation at all.

Mr. Bishop: Not in every case; I did in some rooms, and I added some to the rooms I had not previously heated.

Mr. Geo. D. Hoffman: About four weeks ago I called on a man in New Jersey, an engineer there who had a plant in his building which he had operated for some three or four years as an ordinary low pressure job; he was getting what he called fair economy by heating with that, but he conceived the idea that he could do something better, so he enlarged his diaphragm to 14 inches; that enabled him to control the draft of his boiler so that he had what I would term about 3 ounce pressure; he had a glass water column that was open at the top and this acted as his pressure gauge, the height of the water going up in the water column—he said he never carried water at a greater height than 6 inches in the column—and he had saved during the past two years over 25 per cent. of his fuel, by simply lowering the initial pressure that he had carried more than what was really necessary to circulate the steam through the building. In other words, he never let the steam go above the pressure that was shown in the column of water 6 inches above the water level in the boiler, and he circulated the steam through the entire building with that pressure at

an economy of 25 per cent. less than his other expenditures.

Mr. Bishop: I believe Mr. Brennan's question, as I understand it, was as to whether it was greater economy to raise the boiler pressure and to reduce it near the boilers, than to have the steam manufactured at the pressure needed for circulation. That is a matter we have gone into quite extensively in the way of making experiments on a large scale. We took one plant three years ago that the previous winter had burned 10,130 tons of fuel, during which period steam was circulated at an average of from 20 to 26 pounds, and raised the boiler pressure at the beginning of the season to 60 pounds on the boilers, and reduced it at the boilers to a pressure sufficient for satisfactory circulation, and then every two weeks we raised it ten pounds on the boiler until we got it up to 120 pounds, and on about the first of February then dropped down to 105 pounds—the economy in that plant was very close to 3,000 tons, due to manufacturing steam at the higher pressure and reducing to line pressure. Further than that, there was considerable less temperature and pressure drop in the entire underground heating system. Probably some engineers taking the New York papers, have seen advertisements by the owner of one of the largest department stores in New York City, who not many years ago built a store near Sixth Avenue and Broadway, and who put in a combination exhaust heating and electric lighting and power plant. It was badly managed and allowed to run down in about three years' time. Something over a year ago he contracted with a New York electric light and power company for current for lighting and power purposes, leaving the heating plant to be operated, and last winter his heating plant was operated as a direct heating plant, no exhaust steam being available, buying power and light from the New York company, and no one knows, except himself, I guess, how much more that cost him, but his advertisement is to the effect that "he will give $10,000 to the attorney who will break the contract," which has less than six years yet to run. It has cost him more for his fuel for heating alone than it did for the whole thing, light, heat and power, when he manufactured his steam at high pressure and reduced it through his engines and heated with the exhaust. If anybody can see how that is, I would like to know.

I would like to know also why a pound of steam exhausted from an engine should heat a greater amount of space reduced from high pressure by the engine itself than a like amount of live steam reduced from high pressure through the ordinary types of reducing valves? What I mean by exhaust steam is steam exhausted from reciprocating engines or turbines; why will it heat more space than a pound of steam produced from the same original boiler pressure through a stationary reducing valve?

Mr. Wolfe: What is the truth of that?

Mr. Bishop: On the same station we have been operating both ways at various times and have also compared the quantity of fuel used by one station as against another. Now one of the professors who is a member of this Society has within a year given the following reason. He stated that the boilers delivering the steam at a comparatively constant velocity had somewhat the same effect upon the water in the boiler as a syphon has in a water reservoir, whereas an engine placed between the boiler and the heating plant has supply valve and exhaust valves which are constantly opening and closing, thus reducing to an extent the certain amount of entrained water which would be taken from steam boiler when there was a continuous demand. Of course many theories are advanced, but they do not seem to fully explain the problem.

Mr. Kinealy: I don't think it would take any more steam to *heat*, but I do know this that in the same proportion less steam will be used for power and heating with a given drop of temperature or a given drop of pressure than would be for a given drop of pressure where you heat *alone*. That is, suppose you have a plant where they are using steam at 10 pounds pressure for heating, so that there is a back pressure of 10 pounds on the engine. If you drop the back pressure to zero pounds or half a pound, the economy will be greater in the plant than if you used steam alone for heating at 10 pounds and dropped the pressure to half a pound. The saving would be greater where the steam is used partly for power and partly for heating. It is due to the fact that you make a saving in the amount of steam used for power.

Mr. Donnelly: A number of engineers of large office buildings in New York have told me that between Sunday and

Monday, with the same outside temperature, it costs less on Monday to produce heat and power in the building than it does on Sunday to heat the building alone. It seems to be an established fact that you can produce both power and heat in a building in some cases with less coal than you use to heat it alone.

The President: Were not the buildings referred to by Mr. Donnelly filled with people on weekdays and vacant on Sundays?

Mr. Donnelly: Yes.

The President: Heat will be radiated from the bodies of thousands of people, there is no question about that.

Mr. Donnelly: And in opposition to that is also the fact that when people are in a building they are continually opening doors in going in and out, and considerable cold air enters. Of course a large number of persons in a building make some difference because there is heat from their bodies. But the opening of doors and windows would offset that.

Mr. Harvey: We can heat our whole factory with steam cheaper on Monday than we can over Sunday, that is, it takes less coal. I consider it due to the fact that we pump back all the water of condensation and have a partial vacuum on the heating plant, whereas the steam could not go down but just escape through a drip over Sunday.

Secretary Mackay: The statement was made at one of our annual meetings about one of our largest office buildings in New York, where there was something like 50,000 square feet of radiating surface, that it cost less to heat that building and give it power and electric light during the winter months than it did in the summer months to furnish power and light alone.

Mr. Brennan: Was not that because the heating apparatus condensed all the steam and used it over again?

Mr. Donnelly: I think this explains the old saying that "The last man has the best show."

Mr. Bishop: I want to say that I have made tests on that same proposition up to 30 pounds on a heating apparatus with the same results.

TOPIC NO. 10.

"The relation of heat units per cubic foot and the cost of gas to its economical and possible use in heating water."

DISCUSSION.

Mr. Thompson: I made some experiments a year ago in the matter of the use of gas and the cost of heating hot water for domestic purposes. Incidentally I convinced myself of the fact that the radiation from a given surface increases very rapidly per square foot per degree difference per hour as the temperature difference increases. I was very much interested in the problem as to whether artificial gas at one dollar a thousand could be practically used in supplying domestic hot water, but I have figured out this plan, and my experience justified it: You take the average hot water 30 gallon boiler, 60 by 12 inches, it has about 17 square feet of radiating surface; you take the radiation, which I found was practically correct, of 1.7 B.T.U. per hour per square foot for each degree difference in temperature and at a difference of 70 degrees you will find that the cost will be about seven cents per day for gas at one dollar per thousand. The radiation at 70 degrees difference will require 2,023 B.T.U. per hour. The gas required to make up the loss by radiation, with gas of the heating value of 700 B.T.U. per cubic foot, would be 2.89 cubic feet, or 69.36 cubic feet for a day of 24 hours; the gas required to heat 20 gallons of water 100 degrees is 23.7 cubic feet, costing 2.37 cents, while the cost would be 7 cents a day for the waste by radiation. The point I make is that the use of artificial gas for domestic hot water heating would be entirely practical under any reasonable circumstances if the loss by radiation was removed. Loss by radiation from the average hot water boiler is very great, especially if it is in a cellar. By removing the loss by radiation you would make practical the use of gas for hot water heating.

TOPIC NO. 11

"In a hot air furnace burning five pounds of anthracite coal per square foot of grate per hour, what proportion of heating surface should be provided in relation to the grate surface to insure economy and efficiency?"

DISCUSSION.

Mr. Jones: Inasmuch as five pounds of coal per square foot per hour is a maximum allowance I should say that the heating surface should be 20 square feet for each square foot of grate surface.

Prof. Kent: If we take 10,000 B.T.U. per pound as the amount of heat available in the furnace from good anthracite coal, five pounds per hour will be 50,000 B.T.U. from one square foot of grate. Divide this by the figure which represents the number of B.T.U. that should be transmitted by the heating surface per square foot per hour, say 2,000, and that gives 25 square feet of heating surface per square foot of grate. A smaller proportion of heating surface may of course be used, such as 20 feet, but this will involve a higher rate of transmission of the heating surface and a higher temperature of the chimney gases, which means greater loss of heat.

TOPIC NO. 12.

"When the cubic contents and temperature of the air supply are known, what velocity should be considered when determining the size of the horizontal and vertical pipes and register outlets in a warm air heating system with outside air supply and when the air is circulated, also the size of these air supply ducts and the velocity in them?"

DISCUSSION.

Mr. Thompson: This question is almost impossible of practical answer, because the conditions vary so; you get a higher velocity in some instances than others. I never had any trouble where I had a perfectly straight pipe line and a run of not over 15 feet of getting a velocity in a 10 or 12-inch pipe of 200 to 250 feet per minute, for the first floor registers. On the other hand, where I have had to go around Robin Hood's barn and put two or three angles in, I have not been able to discover I was getting

more than about fifty to one hundred feet; it all depends upon the size of the pipe and the number of angles, the amount of friction and all of that. The question of elimination of friction is the whole point, and I don't believe anybody can succeed who does not work out that problem. If you will calculate your proposition on the basis of the number of cubic feet of air, and then can get up any rule—I don't know of any—by which to determine the amount of friction and the loss of velocity due to bends and angles I think you can solve the problem very quickly. But I have had no trouble in getting a velocity of 200 to 250 feet, with a 7-foot cellar, in a perfectly straight 10 or 12-inch pipe. You can calculate you are getting a much higher velocity in a 12-inch pipe than you will in a 10, other things being equal, and a higher velocity in a 10 than you will in an 8; the velocity is reduced very rapidly as the size of the pipe is decreased, because of the increased friction in the smaller pipe.

Mr. Jones: If the volume of the air supply in cubic feet is known what velocities should be considered? Where there is elevation of one inch in 12, and it is estimated the velocity is 100 feet per minute, may we assume that is correct? I assume it to be; now if the velocity is increased, the area of the pipe might be reduced. If after determining the amount of air to be delivered to the rooms being heated it was found necessary to reduce the velocity, it might be necessary to run a pipe with an elevation less than 1 inch in 12; but it is easier and more practicable to reduce the area of the pipe than it would be to reduce the velocity of the air, and in some cases it might be necessary to run the pipe downward.

TOPIC NO. 13.

"The desirability of accumulating data as to the life of wrought iron and steel pipes in steam and hot water heating systems."

DISCUSSION.

Mr. Chew: I will explain, Mr. President, that Mr. Thompson of the International Correspondence School of Scranton, Pennsylvania, is making an effort to collect data, and I think the topic was introduced to get the members who can to give facts as to the time a given character of iron or steel pipe was placed in the ground or elsewhere, and how long it stood.

Mr. Weinshank: The question is so broad that unless it is specified under what conditions it is almost an impossibility to state the life of a steam pipe, a supply-pipe, a return pipe, or whether it is a high pressure or low pressure pipe, whether it is above ground or under ground or in the building or how; the question is so broad it is almost impossible to cover it with any statement.

The Secretary: The question as I understood it was suggested with a view to the placing of wrought iron or steel pipe as returns underground, with dampness usually on the inside and on the outside of the pipes.

The President: As a matter of information along the lines that this topic seems to suggest, I would say that we had an illustration a short time ago in the city of Philadelphia, in a 9-room dwelling which had a low pressure steam-heating apparatus in it, a steel tube was used to convey the steam, it was a one-pipe job. The condensation was carried back to the boiler; the plant was in use just eight years when it commenced to leak. In taking it out we found that the bottom of the line of pipe—that is, the inside of the pipe on the bottom line—was corroded entirely through, so that when the pipe was held up to the light there was a longitudinal groove in it with holes corroded completely through, although the pipe was only eight years in use. That was one instance where we learned what did occur. That pipe was in a dry place, between the ceiling of the first floor and the floor of the second floor, so that there was no influence brought on it by dampness from the outside, or by concrete or lime or anything of that kind against the outside of the pipe. That was only a case of distilled water taking up the steel and carrying it away. I know of another instance where a 5-inch steam pipe lasted only five months; it was a steel pipe and corroded through in five months.

Mr. Kerr: We have 8-inch wrought-iron pipes that have been in use twenty years which show no wear at all. We have other wrought-iron pipes that have been in four or five months, and we find on examination that a part of the bottom for three-eighths of an inch wide would be eaten away entirely. We have cast-iron pipes eaten from the outside as well as from the inside. Of course that is due to chemical action. But I know in fact that some places this large wrought-iron pipe was just as damp, in a ditch

—in fact it laid in a trench with the covering off, so that it was wet inside and outside, yet it shows no wear on the inside, while the outside was all pitted. If anyone can tell me why a steel pipe will eat up quicker than iron I would like to know. I also would like to know why certain pipes give way at the fittings—we have had any number at least in the basement of houses, both vertical and horizontal pipes, where they were eaten off at the fittings; an inch or two back of the fittings the pipe was full size, and apparently the velocity of the steam or the water had eaten it off at that place; that was a steel pipe. It does not do it with iron. Why is that?

The President: I would like to ask Mr. Kerr whether there was any likelihood of electric current being carried up that pipe referred to?

Mr. Kerr: Not there; we have had cases where electricity did do that, but not in the pipe that I spoke of. We had a dwelling house with conditions similar to the one you mentioned, and it was in the risers running from the basement to the second floor where we had the greatest amount of trouble, and more trouble with vertical pipes than with horizontal pipes.

Mr. May: There are several central heating plants in the suburbs of Chicago which have been installed about five years. Commercial steel pipes have been used in the houses and these pipes are now pitting so that it becomes necessary to replace them. I understand that in the particular locality referred to the water is highly impregnated with magnesia.

Mr. Morgan: Mr. Chairman, I have seen the same thing happen in the bottom pipes of manifold coils, all pitted on the bottom. Now, twenty years ago I don't think they made steel pipes as they make them now. I don't think that the pipe we use to-day begins to weigh anywhere near as much per foot as the pipe we bought twenty years ago, and I have seen pipe taken out that has been in for twenty-five or thirty years that was good and perfectly fit to use again. We are going through the same experience with steel boilers; the old charcoal iron boiler is as good to-day as ever it was, I don't care how many years it has been used. The steel boilers show a badly pitted surface shortly after they have been put in use.

Secretary Mackay: I have experienced similar troubles with the later construction of pipe, which is steel or semi-steel, and I

have attributed it to coming further away from the natural ore. Cast iron will last longer than wrought iron under conditions of dampness in both pipes; you will find that in pipes that are put under ground, whether for water or for gas or anything else, steel pipes will give out much quicker. I know of one case where they put in two or three sets of tubes in a boiler in as many years where one set of tubes, made apparently from the same material, would last three or four times as long. I think that can be traced to the refining of the iron, the taking away from it of properties that should and would lengthen its life.

Mr. Morgan: That calls to my mind an experience I had in Philadelphia. Probably you are familiar with the Wiegand boiler. I went into Mr. Thompson's shop one day and he brought in a boiler that had been in use some twenty odd years to put in new tubes; the old tubes you could take hold of and pinch them right together. They were just as thin as paper, but they were not pitted anywhere, just simply worn out, I presume by the circulation of water, like the Deacon's one-horse shay.

TOPIC NO. 14.

"Chimneys versus Forced Draft and Their Relative Advantages."

DISCUSSION.

Mr. Wing: I believe that, ordinarily speaking, in boiler plants of reasonable size, forced draft is a benefit when we take into consideration the cost of the fuel and the best results we can get from the boiler. Nowadays nearly every one is wanting more power, and it often comes up in plans, whether it is practicable to get an increased power sufficient for the increased business from the present boilers, or whether it is necessary to put in new boilers. I find this condition in many places among the factories throughout the United States. One of the principal points we ought to take up as a Society in connection with the boiler plants is to get rid of the smoke where bituminous coal is used by itself or in combination with anthracite. In taking up the work, even where there are tall chimneys, we find that we can get a great deal of benefit from forced draft.

Among the plants with tall chimneys that we have arranged

to change is the modern plant of the twenty-three story St. Regis Hotel, New York City.

There is no doubt that in a large part of this country and also in Canada and Europe, the smoke issuing from the fires of boilers, locomotives, furnaces, etc., is a serious injury to the health and comfort of the people. Can it be stopped, or at least improved enough to do away with most of the smoke without too great a cost to the owner of the plants and at the same time without increasing the cost of the fuel?

From such tests as I have made and seen others make, I favor a system of forced draft where a small amount of dry, hot steam is used in mixture with the air forced in by the fan into the ash-pit and then by having an auxiliary pipe of the proper size arranged so as to allow a portion of the air with the small per cent. of steam to go into the fire chamber.

This pipe or duct should be placed above the fire doors and have a series of small holes arranged so as to throw jets of air mixed with steam over the fire and in line with the flames or gases as they pass back to and over the bridge wall. The pressure caused by the fan under the grates would send this air through the openings in this pipe or duct in a steady, positive, equal stream, and so far as I know or have seen will give as perfect combustion as is known to-day.

I have also tried the same plan by putting the cross-pipe back of the bridge wall throwing the jets on a slight angle, so as to have the air and steam from the jets fall in with the gases as they come over the bridge wall. I put this system on two boilers in a New York wood-working plant that makes doors, window-sashes, etc., out of soft wood and had enough sawdust, shavings, blocks, etc., to run two 100 horse-power boilers. It was the worst job I ever undertook in this line, but we got the smoke down so that it is not objectionable. Most of the larger cities are enforcing or intend to enforce smoke ordinances, so it is an object for us to get business and at the same time do good work for the people.

TOPIC NO. 15.

"The durability of different kinds of nipples for connecting radiator sections relative to the material, and the capacity to withstand shocks and strains, also the effect on boiler connections."

DISCUSSION.

Mr. Donnelly: I would like to know if any of the members have had any experience with light nipples connecting cast-iron radiator sections rusting out and leaking. The malleable iron nipple, push-nipple, so-called, zinc coated and put between sections of steam and hot water radiators, seems to me very much the same in thickness and in texture as some sheet iron, zinc coated radiators we are getting. It is interesting to know whether the nipples do cut from the ends and rust out, as Mr. Kerr speaks of, and whether it is considered in the trade that the nipple connection between radiators is where the weakest point of the radiator is, or the point in which the radiator is liable to give out. The best nipple we can get is none too good. Probably every effort is being made by the radiator people to get the very best nipples. If there are any radiator men here that can tell us what progress they are making along those lines, what their success has been in prolonging the life of those nipples, I think it would be exceedingly interesting to know about it.

Mr. James Mackay: From my experience the question of connecting nipples cannot be decided quickly. Time is required to demonstrate the element of durability. Screw and slip radiator nipples, used by manufacturers, are made of cast iron, of malleable iron, of drawn tubing and of stamped sheet steel. The sheet metal nipple stamped out of a flat plate and used as a slip nipple has not been found durable, but it has compensated for expansion and contraction. A nipple of seamless drawn tubing tapered and put into the radiator hubs draws together well and seems to have all the elements of durability. It is more rigid than a stamped nipple on account of its thickness. Nipples made of malleable iron seem to be good. One manufacturer tells me he has used slip radiator nipples made of brass tubing offset at a slight taper and drawn

together. This would seem to be practically indestructible. Right and left screwed nipples are often made of heavy cast iron. I don't think they will stand a severe shock, although they do stand ordinary shocks met with in transportation. They are made heavy and strong, with thick, deep threads; are put together with gaskets, drawing the two faces up against the gasket. This nipple is perhaps more of a hollow stay-bolt than anything else.

The President: You are speaking of radiator nipples?

Mr. James Mackay: Yes, sir; right and left threaded nipples and slip or push nipples. The trouble with nipples, as I find it, is that you may devise a nipple and coat it with non-corrosive material and seemingly it will answer the purpose, but it takes a number of years to determine whether it will be durable or not. A great many nipples have been used, and, after five, six, or seven years' service, the radiator is found to be practically without a nipple. They rust out. This gives rise to the use of thicker material and while that also will rust, it will wear much longer. My idea is that a heavy malleable iron push nipple is about as good a nipple as can be devised. I would like to hear the experience of others with this problem.

Mr. Kerr: The question of nipples in radiation is of very great importance to all Central Station heating men. Mr. Mackay brings up the question of the malleable iron nipple. Now we have been driven to use nearly everything that has been brought out on the market. The malleable iron slip nipple seemed to offer us a means of getting out of our difficulty—we rebuilt probably thirty thousand feet of radiation with malleable iron nipples. Now the difficulty with them has been that when building up the radiation it would test out all right, and it would stay six months before it would commence to leak; the leaking usually came on in the beginning of mild weather in the spring when the radiator was turned on or turned off. Sometimes one or two of the nipples in the radiator and then again nearly every one of the nipples that had been in operation for six months would commence to leak. When we commenced setting our slip nipple radiation some nine or ten years ago the nipple was turned out of heavy wrought iron pipe; those nipples, if I remember rightly, stayed

a little over six years before we began to have any trouble. With the nipple pressed from spun pipe, the upsetting of the nipple opened up a grain in the centre at the point of greatest diameter. We found that those nipples would last all the way from two weeks to a couple of years, then they had to be replaced. It became such a great nuisance that we have now entirely abandoned slip nipple radiation on the central station. Now, if there is anything new in a slip nipple we would like to get hold of it—we have troubles of our own on that point.

The President: I would like to ask Mr. Kerr whether he is using a threaded nipple now, or how he is connecting his radiators, and whether he found more leaks in the water radiators than he did in the steam radiators?

Mr. Kerr: I have been speaking of producing radiation with water from a central station plant under a maximum pressure of 30 pounds at the radiator. We have found that the screwed nipple radiator is the only radiator so far that we have been able to put in without getting us into trouble. We have had those on the line now ten years without any apparent depreciation in that radiator in any form.

The President: Isn't it likely that the leak was caused in the water radiator by the top line of nipples becoming heated when the bottom line of nipples was cold, and it was caused by the action of the main—the creeping action of the top and the bottom, that is the top of the radiator expanding when the bottom was not so hot and giving that breaking motion; isn't it more than likely that that would be the cause of the trouble?

Mr. Kerr: Without a doubt that caused a great deal of the trouble with the malleable iron nipple; not, however, with the other.

The President: Did the bottom nipple leak more than the top nipple?

Mr. Kerr: In the malleable iron the bottom nipple gave us more bother than the upper; in the pressed steel nipple there was practically no difference, wherever there happened to be an impurity in the steel it practically opened up at that point.

Mr. McCann: In the New York schools several years ago the standard was push nipples for all radiators and we had a great deal of trouble with the push nipples wearing out. And about the same time we used a screw nipple with a rubber

gasket with both water and steam, and that gave a great deal of trouble, so that we had to take those radiators out entirely. Since the application of cast iron screw nipples, right and left, made up so tight that the nipples themselves make tight joints, and not depending on paper or any other packing, we have had no trouble with the radiation on that score.

TOPIC NO. 16.

"How would you measure the surface of a wall radiator to obtain the actual number of square feet it contained?"

DISCUSSION.

Mr. McCann: The reason I ask the question is that various radiator manufacturers come to me and say that their opponents are not furnishing full rating, and I would like to be able to say yes or no.

Mr. Morgan: As a matter of fact, Mr. President, it is the effectiveness of the radiator that we go for. If we can get as much service out of one foot of one kind of radiator as we can out of two feet of the other, there is no use in buying two feet. Professor Kinealy, I think, could answer that problem all right. He says take a piece of string and measure the string. I don't know just how the operation should be performed; maybe he will enlighten us on that subject.

Mr. Kinealy: This is a question that I always fight shy of, because every time I have had occasion to measure up the surface of a section of radiator I have gotten into a dispute as a result of the measurement. It seems to me that the only way we can do is to pass a string around the section and get the circumference in that way and then find the length of the section and multiply that by the circumference of the loop. The objection to that is that if there are ornaments on the surface it becomes a question whether you should pass the string in measuring their circumference into each one of the small indentations or ornamentations, or whether you should neglect those and take simply the circumference as measured as closely as possible where there are no ornamentations. I don't think that the sections that are rated by the manufacturers will differ very much from one another in area, because if they do then on

tests one section will be found to condense more steam than the other, and as soon as that happens the manufacturer of that particular section advertises at once that on tests his section will condense five or ten or twenty per cent. more steam per square foot of surface than the other manufacturer's, and he makes that a selling point.

Mr. McCann: In public work it is very often necessary to state the exact number of square feet you have figured on, and in one case in my connection with the Board of Education in New York, the radiator maker brought a sample up and asked to have it approved by the Board of Education. It was carefully measured by the chief draughtsman by cutting it up into sections and measuring the figures thus formed and it came a very little bit short of the five or five and one-half square feet that it was rated at. The manufacturer simply added a pair of ears on the top and got it up to the $5\frac{1}{2}$ feet.

Secretary Mackay: I have had considerable experience measuring radiators in the way Professor Kinealy has mentioned, and I have also known of them being completely covered with paper and that paper again spread out and pasted on a flat surface and measured, so as to find out whether it had the surface that was claimed for it. I have known of cases where direct radiators were found to be short of the claimed surface, and that was overcome by putting an eighth of an inch of bead entirely around the radiator. It was a slightly extended surface but was considered to be fairly effective, more so than some other forms of extended surface.

Mr. Kinealy: Whenever I find that it is likely that I have got to go up against that problem of measuring, I simply specify straight what I want. If I want Jones's machine, I specify Jones's machine——

Mr. McCann: We can't do that in public work.

Mr. Kinealy: If it is a radiator, I specify whether it shall be 2, 3 or 4 columns, and the height; cast iron, or what not. And then in noting the size on the drawings I put the number of loops or columns to the radiator as well as the size, so that in checking up the sizes all I have got to do is to count the loops.

Mr. Morgan: Mr. President, it is clearly within the memory of the older members of the profession that when this conden-

sation practice of rating radiators was going on that the fellow that told the last story always had the best of it; you will remember that. I call to mind a radiator that was made in the East entirely filled up with slabs and bars, and it got more condensation than anybody else's, until somebody got after it. Now the question of surface in the loop can be determined. The extended surface idea, I think, has gone out practically; we don't hear so much about that as we used to. But the manner in which the surfaces of the radiator are put together cuts a very great figure in the effectiveness of the radiator, in my opinion. I think that is another part of the problem that might be discussed with benefit to all.

Secretary Mackay: I agree with Mr. Morgan that more important than having a certain amount of surface or the exact amount of surface that is claimed for in the radiator is the condensing power of the radiator. Sufficient air space should be left between sections so that air can be got to all of the surfaces to make it effective. We have radiators that have the surfaces claimed for them, but they are so placed, so closely massed together, that it is impossible to utilize the surface that is in the radiator; and that same radiator with less surface more spread out would be better.

Mr. Donnelly: I believe that competition among radiator men of every kind will make it so that they will give us the best radiators, and I think the most profitable competition would be for a man who could take a radiator weighing, say 100 pounds, and get the most work out of it, provided it was made of thick enough iron to be durable. For in the last analysis the man who can do the most work with a given weight of material is producing the best result. I believe that with a hundred pounds of iron and a reasonable amount of extended surface more condensation can be produced and more heat gotten out of a hundred pounds of iron properly cast into a radiator than a hundred pounds of iron of prime surface. From the fact that the extended surface, if reasonable in extent, would be quite thin, and give us in effective work more duty from the same weight of iron.

Secretary Mackay: The only objection I see to what Mr. Donnelly suggests is that most manufacturers of radiators try to get all they can out of the patterns as well as out of their

product, and that while extended surface to a limited extent is efficient in steam radiation, possibly almost as of prime surface, the same does not apply to hot water radiation, and that the same patterns would not answer to make hot water radiators from and the result would be to increase the manufacturer's cost for patterns. That has already driven some patterns of radiators out of the market, but I think on that question it would be better to discard the use of extended surface radiation where there is a possibility of its being used for both purposes. I have had experience where extended surface radiation was put in, for hot water heating, the 7-foot loop would be equal to 5 feet, which would be practically no more than the actual prime surface that was in the radiator and the iron that was in the extended surface was a pure loss. The manufacturer, perhaps, got paid for it, the house owner and the fitter, they suffered, every one of them, the manufacturer in the reputation of his radiator, the fitter because he did not give satisfactory results, and the owner because he did not obtain satisfactory results from extended surface radiation for hot water.

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